Radiological Health Data

VOLUME IV, NUMBER 11

NOVEMBER 1963

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis and interpretation of data on environmental radiation levels. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

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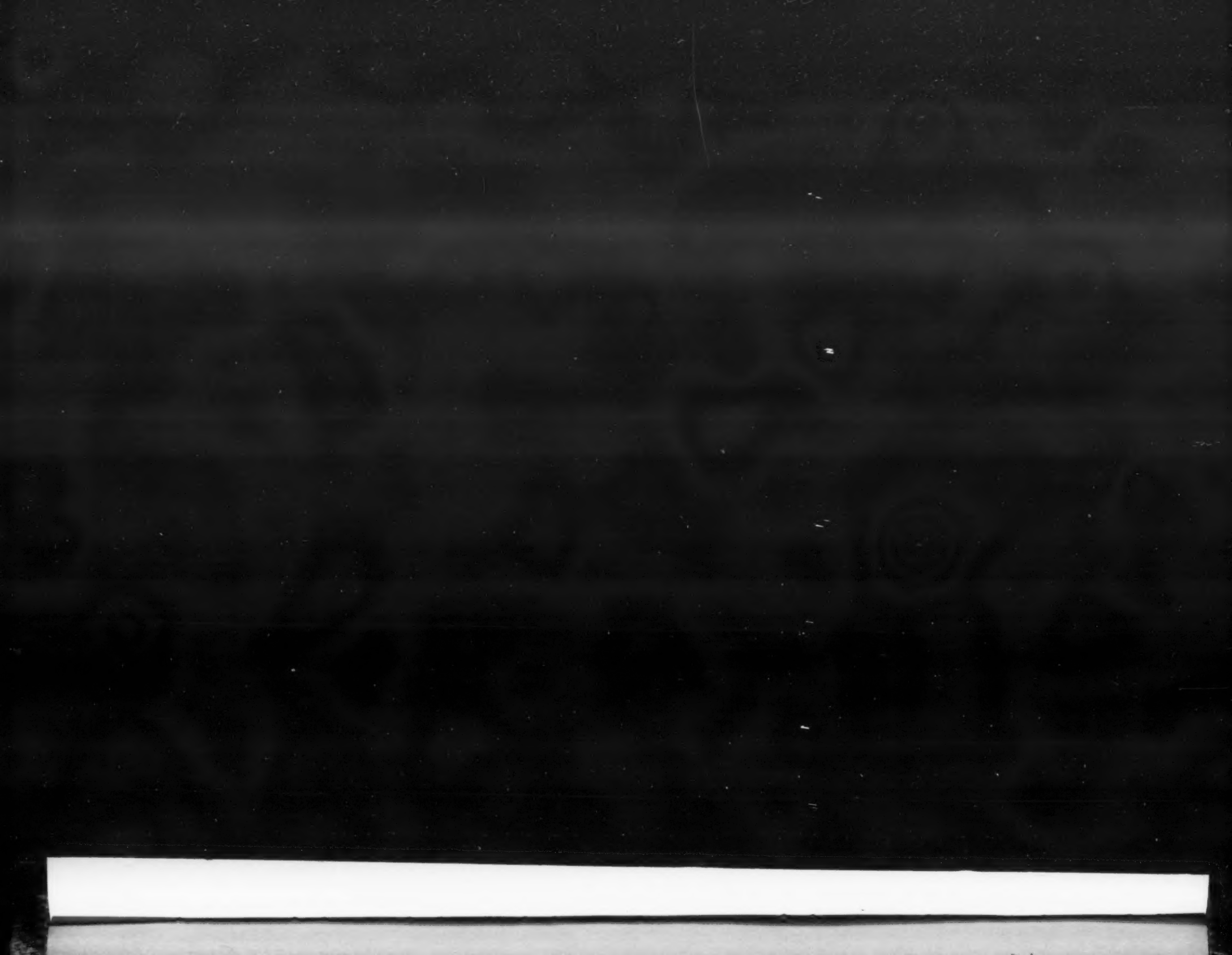

RADIOLOGICAL HEALTH DATA

VOLUME IV, NUMBER 11
NOVEMBER 1963

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

November 1963

SECTION I.—AIR AND FALLOUT

Fission Product Beta Activity in Airborne Particulates and Precipitation

Early indications of possible fission product activity fluctuations in various phases of the environment are detectable by continuous surveillance of gross beta activity in air and precipitation. This form of surveillance does not provide sufficient information for assessing human exposure due to fallout, but it forms a basis for an alerting system and is useful in determining when and where to conduct more extensive monitoring of radioactivity in food, milk, and water.

Gross beta concentrations in air for July 1963 are presented in reports from the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican National Commission of Nuclear Energy, and the Pan American Health Organization. Network intercalibration factors, determined by Lockhart and Patterson (*1*), were used in constructing the isogram map (figure 5), which presents data on Canadian and U.S. gross beta radioactivity in air for July. To adjust the data from the two networks to a common baseline, the U.S. data were multiplied by a factor of 1.54, the U.S.–Canadian intercalibration factor suggested by the NRL study.

REFERENCE

(*1*) Lockhart, L. B. Jr., and R. L. Patterson, Jr.: *Intercalibration of Some Systems Employed in Monitoring Fission Products in the Atmosphere, NRL Report 5850*, Naval Research Laboratory, Washington, D.C. (November 13, 1962); abstracted in *Radiological Health Data*, December 1962.

RADIATION SURVEILLANCE NETWORK July 1963

Division of Radiological Health,
Public Health Service

The Radiation Surveillance Network (RSN) is made up of 72 sampling stations distributed throughout the United States (see figure 1). Most of these stations are operated by State Health Department personnel.

Air

Daily 24-hour air samples are collected on a 4-inch diameter, carbon-loaded cellulose dust filter in a high-volume air sampler. Field estimates of the gross beta activity of airborne particulates are derived by comparing portable survey meter readings of these filters with readings taken from a Sr^{90}–Y^{90} standard. This determination is usually made about 5 hours after the end of the sampling period to eliminate interference from naturally-occurring radon daughters. The Network's station operators report their field estimates daily by telephone to the Radiation Surveillance Center, Division of Radiological Health, Washington, D.C. From this information, a daily national report is prepared.

The filters are then forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, for a more refined measurement using a thin-window, gas-flow proportional counter, calibrated with a 40,000-pc Sr^{90}–Y^{90} standard. Each filter is counted at least 3 days after the end of the sampling period and is re-counted 7 days later. The initial 3-day aging of the sample eliminates interference from naturally-occurring radon and thoron daughters. From the two counts, which are separated by the 7-day interval, it is possible to estimate the age of fission products and to extrapolate the activity to the time of collection. The extrapolation is performed by using the Way-

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS, JULY 1963

Wigner formula: $AT^{1.2}$ = constant (*1*).[1] The daily concentrations and estimated age are reported by the PHS in a monthly RSN report (*2*).

The average fission-product beta concentrations in surface air during July 1963, as determined by laboratory analysis and extrapolated to the time of collection, are given in table 1. These data (adjusted by the intercalibration factor 1.54),[2] together with corresponding Canadian data, are represented by isogram lines in figure 5, which show the distribution of fission product activity over most of North America.

Precipitation

Continuous sampling for total precipitation is conducted at most stations on a daily basis, using funnels with collection areas of 0.4 square meter. A 500–ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory to be counted by the same method used for analyzing the air samples, including extrapolation to the time of collection. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made. July 1963 averages of gross beta activity in precipitation, expressed as picocuries per liter and as nanocuries per square meter, are presented in table 2.

Profiles

The profiles of the monthly average fission product beta activity in airborne particulates for each RSN station covering the period of time from the formation of the network in 1956 to the end of 1960 were published in the July 1961 issue of *RHD*. The profiles of 7 stations, through July 1963, are shown in figure 2.

[1] In this expression, A is the activity and T is the time after fission product formation.

[2] See reference *1* on page 543.

REFERENCES

(*1*) Way, K., and E. P. Wigner: The Rate of Decay of Fission Products, *Physical Review*, *73*:1318–30 (June 1948).
(*2*) Radiation Surveillance Network: *Monthly Tabulation of Findings*, Division of Radiological Health, Public Health Service, Washington 25, D.C. (Distribution by official request).

TABLE 1.—FISSION PRODUCTS GROSS BETA ACTIVITY IN SURFACE AIR—RSN, JULY 1963

[Concentrations in pc/m³]

Station location		Number of samples	Maximum	Minimum	Average [a]	Last profile in RHD
Alaska:	Adak	28	5.2	<0.10	1.2	Nov. 63
	Anchorage	31	2.6	0.21	1.4	Jul. 63
	Attu	31	6.6	0.11	2.0	Dec. 62
	Fairbanks	29	6.2	0.12	2.5	Aug. 63
	Juneau	28	3.2	0.14	1.4	Sep. 63
	Kodiak	28	4.5	<0.10	1.2	Oct. 63
	Nome	0	—	—	—	Feb. 63
	Point Barrow	29	3.5	<0.10	1.1	Mar. 63
	St. Paul Island	19	4.6	<0.10	1.0	Apr. 63
Ariz.:	Phoenix	31	7.8	1.8	4.0	Sep. 63
Ark:	Little Rock	28	12	0.91	4.4	Sep. 63
Calif:	Berkeley	30	4.5	0.71	2.0	Oct. 63
	Los Angeles	22	6.6	2.1	4.5	Feb. 63
Colo:	Denver	25	7.6	1.4	4.0	Nov. 63
Conn:	Hartford	30	8.1	1.2	4.3	Oct. 63
Del:	Dover	20	14	2.4	7.2	Aug. 63
D.C:	Washington	31	13	3.3	7.0	Mar. 63
Fla:	Jacksonville	28	8.4	0.96	3.6	Oct. 63
	Miami	29	5.4	1.5	3.1	Feb. 63
Ga:	Atlanta	23	12	1.4	5.0	Jul. 63
Guam:	Agana	29	1.0	<0.10	0.39	Mar. 63
Hawaii:	Honolulu	31	5.1	0.31	2.3	Nov. 63
Idaho:	Boise	29	17	1.9	9.3	Dec. 62
Ill:	Springfield	30	8.1	1.7	5.0	Oct. 62
Ind:	Indianapolis	30	9.2	2.0	5.4	Jul. 63
Iowa:	Iowa City	31	7.7	1.8	4.6	Nov. 62
Kans:	Topeka	31	9.0	1.5	4.6	Jul. 63
Ky:	Frankfort	31	9.5	1.5	4.8	Mar. 63
La:	New Orleans	30	5.0	1.0	2.5	Nov. 62
Maine:	Augusta	30	9.6	0.53	4.9	Mar. 63
	Presque Isle	30	10	1.2	4.0	Nov. 63
Md:	Baltimore	21	9.6	2.7	5.9	Nov. 63
	Rockville	13	8.7	2.6	5.3	[b]
Mass:	Lawrence	28	12	1.9	5.8	Aug. 63
	Winchester	26	9.9	1.7	5.0	[b]
Mich:	Lansing	31	9.2	2.1	5.9	Apr. 63
Minn:	Minneapolis	30	7.6	1.5	4.7	Mar. 63
Miss:	Jackson	27	7.7	1.4	3.6	Mar. 63
	Pascagoula	8	3.0	0.54	1.6	Nov. 62
Mo:	Jefferson City	30	7.0	1.3	4.5	Nov. 63
Mont:	Helena	29	12	1.4	6.4	Nov. 63
Nebr:	Lincoln	15	13	2.1	5.2	Apr. 63
Nev:	Las Vegas	30	15	3.3	8.3	Jul. 63
N.H:	Concord	18	12	1.2	6.4	[b]
N.J:	Trenton	31	9.4	1.9	4.9	Oct. 62
N. Mex:	Santa Fe	29	5.2	1.1	2.6	Dec. 62
N.Y:	Albany	31	9.8	1.4	5.2	Jul. 63
	Buffalo	27	9.4	2.9	6.1	Nov. 63
	New York	20	8.6	1.3	4.8	Dec. 62
N.C:	Gastonia	30	13	1.9	5.7	Oct. 62
N. Dak:	Bismarck	29	9.9	2.4	5.6	Feb. 63
Ohio:	Cincinnati	22	7.0	1.8	4.6	Aug. 63
	Columbus	31	9.7	2.6	5.2	Feb. 63
	Painesville	30	10	3.0	7.0	Oct. 63
Okla:	Oklahoma City	29	5.1	1.1	2.7	Apr. 63
	Ponca City	30	5.7	0.70	2.0	Oct. 63
Ore:	Portland	30	8.2	1.3	3.6	Oct. 63
Pa:	Harrisburg	23	8.1	0.80	4.2	Dec. 62
P.R:	San Juan	31	4.4	0.65	3.0	Apr. 63
R.I:	Providence	29	10	1.9	5.2	Nov. 62
S.C:	Columbia	28	8.4	1.1	3.7	Dec. 62
S. Dak:	Pierre	30	7.7	1.9	4.1	Sep. 63
Tenn:	Nashville	29	14	1.3	6.0	Feb. 63
Tex:	Austin	29	4.2	1.1	2.3	Aug. 63
	El Paso	29	3.9	0.38	1.9	Feb. 63
Utah:	Salt Lake City	31	15	2.3	5.4	Aug. 63
Vt:	Barre	31	10	1.0	5.6	Sep. 63
Va:	Richmond	31	9.2	1.7	4.6	Sep. 63
Wash:	Seattle	30	3.7	0.82	1.8	Jul. 63
W. Va:	Charleston	28	8.0	1.8	4.5	[b]
Wisc:	Madison	29	11	2.5	6.8	Sep. 63
Wyo:	Cheyenne	31	9.3	1.4	4.4	Aug. 63
Network summary		1,966	15	<0.10	4.2	

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10% of the average, a less-than sign is placed in front of the average.

[b] Initial profile scheduled for a future issue.

TABLE 2.—GROSS BETA ACTIVITY IN PRECIPITATION—RSN, JULY 1963

Station location		Average concentration (pc/liter)	Total deposition [a] (nc/m²)
Alaska:	Anchorage	2,000	110
	Fairbanks	1,100	45
	Juneau	1,100	150
Ark:	Little Rock	510	53
Calif:	Berkeley	[b]—	[b]—
	Los Angeles	—	—
Colo:	Denver	—	—
Conn:	Hartford	1,900	140
D.C:	Washington	2,700	68
Fla:	Jacksonville	530	98
	Miami	820	15
Ga:	Atlanta	590	12
Idaho:	Boise	—	—
Ill:	Springfield	—	—
Ind:	Indianapolis	820	83
Iowa:	Iowa City	780	110
Kans:	Topeka	510	32
Ky:	Frankfort	1,000	41
La:	New Orleans	820	140
Maine:	Augusta	1,800	130
	Presque Isle	1,200	88
Md:	Baltimore	2,500	99
Mass:	Lawrence	2,500	180
	Winchester	2,100	94
Mich:	Lansing	700	42
Minn:	Minneapolis	1,200	53
Miss:	Jackson	1,400	150
Mo:	Jefferson City	820	53
Mont:	Helena	5,000	98
Nebr:	Lincoln	1,400	69
Nev:	Las Vegas	—	—
N.J:	Trenton	1,300	27
N. Mex:	Santa Fe	1,200	39
N.Y:	Albany	1,000	38
	Buffalo	—	—
N.C:	Gastonia	860	40
N. Dak:	Bismarck	2,000	110
Ohio:	Columbus	1,500	120
	Painesville	1,200	97
Okla:	Oklahoma City	540	35
	Ponca City	420	71
Ore:	Portland	740	22
Pa:	Harrisburg	970	33
P.R:	San Juan	480	44
R.I:	Providence	2,500	230
S.C:	Columbia	1,200	130
S. Dak:	Pierre	1,100	110
Tenn:	Nashville	1,200	110
Tex:	Austin	780	0.98
	El Paso	680	13
Utah:	Salt Lake City	—	—
Vt:	Barre	1,400	110
Va:	Richmond	1,400	14
Wash:	Seattle	2,000	40
W. Va:	Charleston	850	76
Wisc:	Madison	940	75
Wyo:	Cheyenne	1,900	16

[a] Depth of precipitation (mm) = $\frac{\text{deposition (nc/m}^2\text{)} \times 1000}{\text{concentration (pc/liter)}}$

[b] Dash indicates no evaporated sample received.

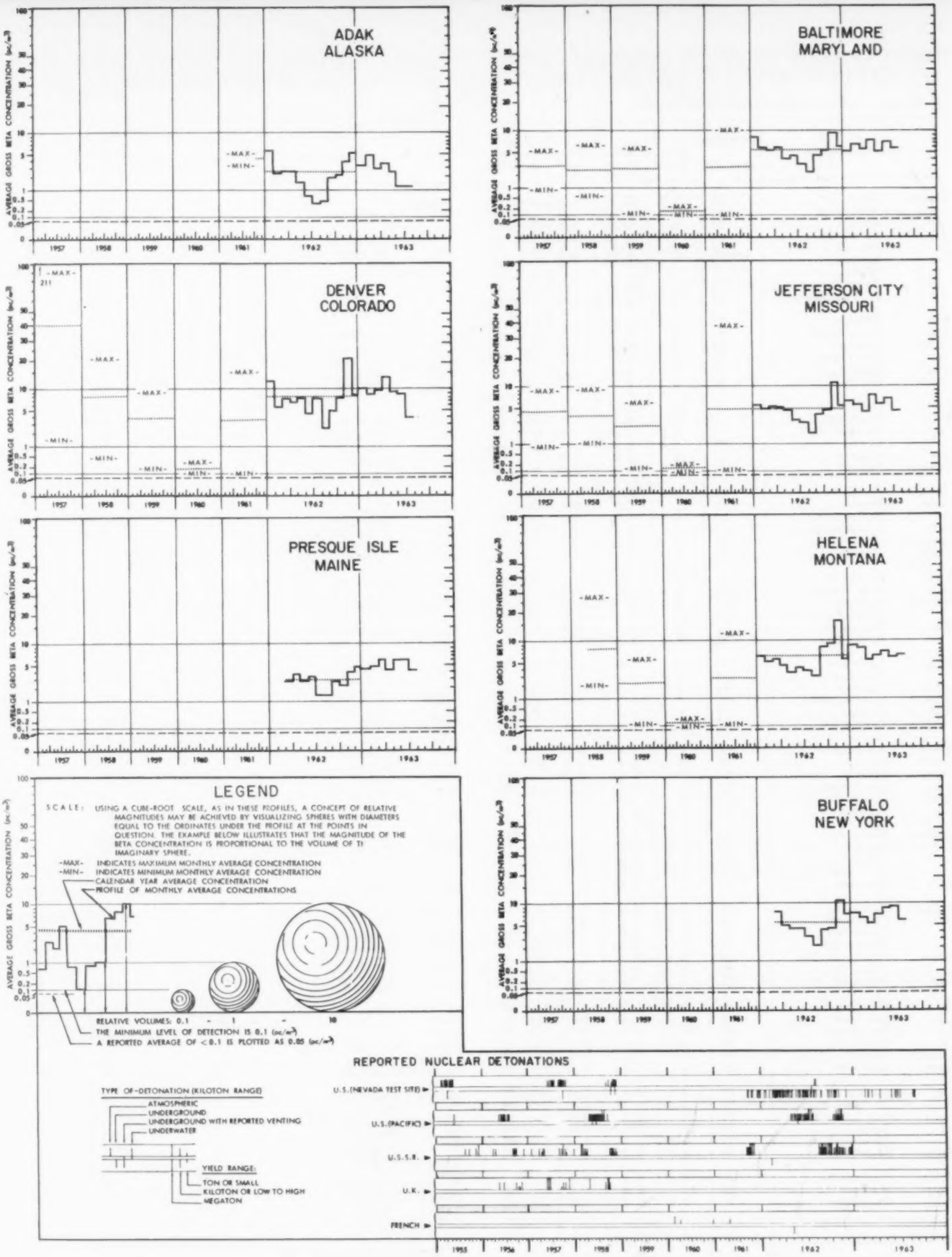

FIGURE 2.—MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR—RADIATION SURVEILLANCE NETWORK, 1957—JULY 1963

CANADIAN AIR MONITORING PROGRAM
July 1963

Department of National Health and Welfare, Ottawa, Canada

As part of its Radioactive Fallout Study Program (RFSP), the Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation. Twenty-four RFSP collection stations are located at airports (see figure 3) where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

Air

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch-diameter filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is cut from each filter and counted with a thin-end-window, gas flow Geiger-Mueller counter system, calibrated with a Sr^{90}–Y^{90} standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission pro-

TABLE 3.—FISSION PRODUCTS GROSS BETA ACTIVITY IN AIR—RFSP, JULY 1963

[Average concentrations in pc/m³]

Station	Number of samples	Maximum	Minimum	Average
Calgary	31	20.8	3.3	9.7
Coral Harbour	30	11.8	0.4	4.4
Edmonton	31	12.0	1.2	7.2
Ft. Churchill	30	10.0	0.1	3.6
Ft. William	30	16.2	0.3	7.3
Fredericton	31	13.3	1.8	5.4
Goose Bay	31	16.2	0.1	5.6
Halifax	31	15.0	1.6	6.0
Inuvik	31	18.7	1.1	5.1
Montreal	30	15.4	1.2	7.6
Moosonee	30	17.0	1.1	6.9
Ottawa	31	21.3	1.3	7.9
Quebec	31	17.1	0.6	6.7
Regina	31	26.7	3.3	9.4
Resolute	30	4.6	0.2	1.9
St. John's	28	12.5	0.6	4.1
Saskatoon	31	28.0	1.0	11.7
Sault Ste. Marie	31	14.9	0.4	8.8
Toronto	31	12.5	0.7	7.7
Vancouver	31	9.2	1.7	4.0
Whitehorse	31	11.0	0.7	4.5
Windsor	31	16.8	4.2	9.6
Winnipeg	31	20.8	0.4	8.7
Yellowknife	31	18.3	0.6	5.0
Network summary	735	15.8	1.2	6.6

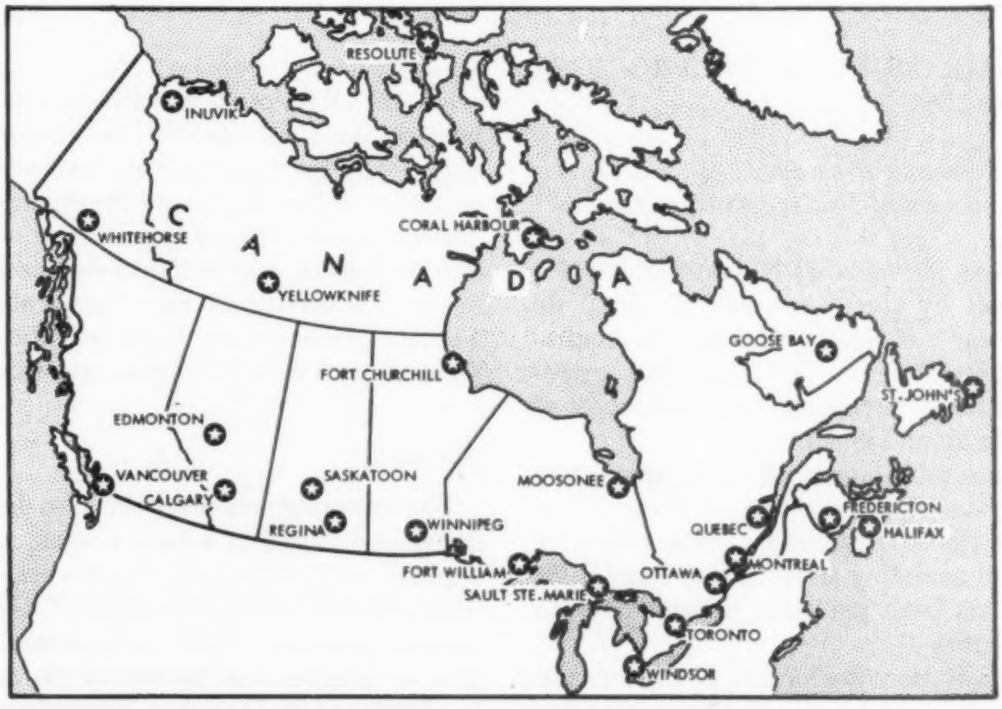

FIGURE 3.—CANADIAN AIR AND PRECIPITATION SAMPLING STATIONS, JULY 1963

TABLE 4.—FISSION PRODUCT GROSS BETA ACTIVITY IN PRECIPITATION—RFSP, JULY 1963

Station	Total beta activity	
	nc/m²	pc/liter
Calgary	411.8	4,559
Coral Harbour	116.1	4,866
Edmonton	259.2	3,991
Ft. Churchill	190.1	2,805
Ft. William	119.7	4,249
Fredericton	257.0	2,164
Goose Bay	216.5	1,050
Halifax	130.9	2,344
Inuvik	154.4	2,504
Montreal	[a]—	[a]—
Moosonee	184.7	3,622
Ottawa	212.6	2,636
Quebec	157.5	1,219
Regina	282.5	2,129
Resolute	[b]	[b]
St. John's	96.9	1,405
Saskatoon	331.8	4,494
Sault Ste. Marie	173.5	3,106
Toronto	144.9	2,562
Vancouver	126.4	1,961
Whitehorse	77.3	2,308
Windsor	125.7	2,949
Winnipeg	—	—
Yellowknife	177.8	3,320
Average	188.0	2,869

[a] Dash indicates no analysis.
[b] Blank space indicates no sample.

ducts. The results are extrapolated to the end of the sampling period. Canadian air data for July 1963 are given in table 3 and presented in conjunction with U.S. adjusted air data by the isogram map (figure 6).

Precipitation

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polythene-lined rainfall pots. After transfer of the water to the sampling container the polythene liner is removed, packed with the sample, and sent to the laboratory. Beta activities in precipitation for stations in Canada are presented in table 4.

REFERENCES

(1) Bird, P. M., A. H. Booth, and P. G. Mar: *Annual Report for 1959 on the Radioactive Fallout Study Program, CNHW–RP–3*, Department of National Health and Welfare, Ottawa, Canada (May 1960).

(2) Bird, P. M., A. H. Booth, and P. G. Mar: *Annual Report for 1960 on the Radioactive Fallout Study Program, CNHW–RP–4*, Department of National Health and Welfare, Ottawa, Canada (December 1961).

(3) Mar, P. G.: *Annual Report for 1961 on the Radioactive Fallout Study Program, CNHW–RP–5*, Department of National Health and Welfare, Ottawa, Canada (December 1962).

(4) Beale, J. and J. Gordon: *The Operation of the Radiation Protection Division Air Monotoring Program, RPD–11*, Department of National Health and Welfare, Ottawa, Canada (July 1962).

(5) Booth, A. H.: *The Calculation of Maximum Permissible Levels of Fallout in Air and Water and Their Use in Assessing the Significance of 1961 Levels in Canada, RPD–21*, Department of National Health and Welfare, Ottawa, Canada (August 1962).

MEXICAN AIR MONITORING PROGRAM
April and May 1963

Radiological Protection Program
National Commission of Nuclear Energy, Mexico

The Radiation Surveillance Network of Mexico was established by the "Comision Nacional de Energía Nuclear" (CNEN) through its Radiological Protection Program (RPP) in 1961 to provide a means for determining increased levels of radioactivity in air and precipitation.

Prior to the establishment of the network, two pilot sampling stations were set up (in Mexico City and San Luis Potosí), to aid in the selection of equipment and sampling sites. Since April 1962 the network has been gradually expanded to 15 stations (see figure 4).

Ten of the 15 stations are located at airports and operated by airline personnel. The remaining five stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí, and Ensenada. Staff members of the RPP operate the station at Mexico City, while the other four stations are manned by members of the Centro de Prevision del Golfo de Mexico, the Chemistry Department of the University of Mérida, the Instituto de Zonas Deserticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air for 24 hours a day, 3 or 4 days a week, at the rate of approximately 1,200 cubic meters per day, through a high-efficiency glass fiber filter, 6″ x 8″, using high volume samplers. After each 24-hour period, the filter is removed and forwarded via airmail to the "Laboratorio de Desechos Radiactivos," CNEN, in Mexico City for assay of gross beta activity. A

FIGURE 4.—FALLOUT NETWORK SAMPLING STATIONS IN MEXICO

minimum of 3 or 4 days after collection is allowed for decay of radon and thoron daughters' natural radioactivity. Data are not extrapolated to time of collection.

The maximum, minimum, and average concentrations of fission product beta activity in surface air during April and May 1963 are presented in tables 5 and 6.

TABLE 5.—GROSS BETA ACTIVITY OF AIRBORNE PARTICULATES—MEXICO, APRIL 1963

[Concentrations in pc/m³]

Station	Number of samples	Maximum	Minimum	Average
Acapulco	11	12.8	3.1	7.5
Ciudad Juárez	16	23.5	5.1	11.2
Ensenada	11	23.0	3.9	8.1
Guadalajara	6	17.7	4.6	8.3
La Paz	13	16.8	4.1	8.8
Mérida	15	18.0	4.8	8.0
México, D.F.	14	20.8	2.3	7.4
Nuevo Laredo	4	10.7	5.9	8.6
San Luis Potosí	7	14.4	6.6	9.7
Torreón	14	19.3	2.9	6.7
Tuxtla Gutierrez	15	15.1	3.2	6.3
Veracruz	25	17.1	5.8	8.8
Tampico	6	9.6	4.5	6.3
Matamoros	10	10.1	5.7	7.3
Network summary	167	23.5	2.3	8.1

[a] Because the counting system was out of order the samples were counted an average of 40 days after collection. Data are not extrapolated to time of collection.

TABLE 6.—GROSS BETA ACTIVITY OF AIRBORNE PARTICULATES—MEXICO, MAY 1963

[Concentrations in pc/m³]

Station	Number of samples	Maximum	Minimum	Average
Acapulco	4	9.4	2.9	5.7
Ciudad Juárez	15	16.4	2.3	6.9
Chihuahua	4	22.7	5.5	10.5
Ensenada	10	6.8	1.6	4.6
Guadalajara	12	15.5	3.2	6.0
La Paz	8	13.1	7.2	9.5
Matamoros	22	9.0	2.9	5.8
Mérida	17	9.1	2.1	5.3
México	14	7.8	1.0	4.4
Nuevo Laredo	6	8.8	4.4	7.3
San Luis Potosí	13	9.2	0.9	5.4
Tampico	13	7.8	3.2	5.8
Torreón	17	8.7	3.8	5.8
Tuxtla Gutierrez	17	15.2	3.3	7.4
Veracruz	16	11.0	3.5	6.6
Network summary	188	22.7	0.9	6.9

Recent coverage in *Radiological Health Data:*

Period	*Issue*
January 1963	*May 1963*
February 1963	*June 1963*
March 1963	*July 1963*

PAN AMERICAN AIR SAMPLING PROGRAM
July 1963

Pan American Health Organization and Public Health Service

Gross beta activity in air is being monitored at three locations in South America under the auspices of a collaborative radiological health program between the Pan American Health Organization (PAHO) and the Public Health Service (PHS).

The three air sampling stations presently included in the program are located in Santiago, Chile; Lima, Peru; and Caracas, Venezuela. The Caracas station was activated in November 1962 and the other two stations entered in December of the same year.

The air sampling stations are manned by local personnel, and the sampling equipment and laboratory analyses are provided by the Public Health Service. Equipment and counting procedures are identical with those employed for the Radiation Surveillance Network.

Fission product gross beta activity data for July 1963 are presented in table 7. The higher monthly average values noted for Caracas, in comparison with values for corresponding months for Lima and Santiago, are consistent with the Northern Hemisphere location of the Caracas station.

TABLE 7.—GROSS BETA ACTIVITY IN AIR—PAASP, JULY 1963

[Concentrations in pc/m³]

Sampling stations	No. of samples	Maximum	Minimum	Average[1]
Caracas, Venezuela	22	2.43	0.26	0.93
Lima, Peru[2]	0			
Santiago, Chile	5	0.21	<0.10	<0.15

[1] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10% of the average, a less-than sign is placed in front of the average.

[2] The Lima, Peru, station was not in operation during the month of July because of mechanical difficulties.

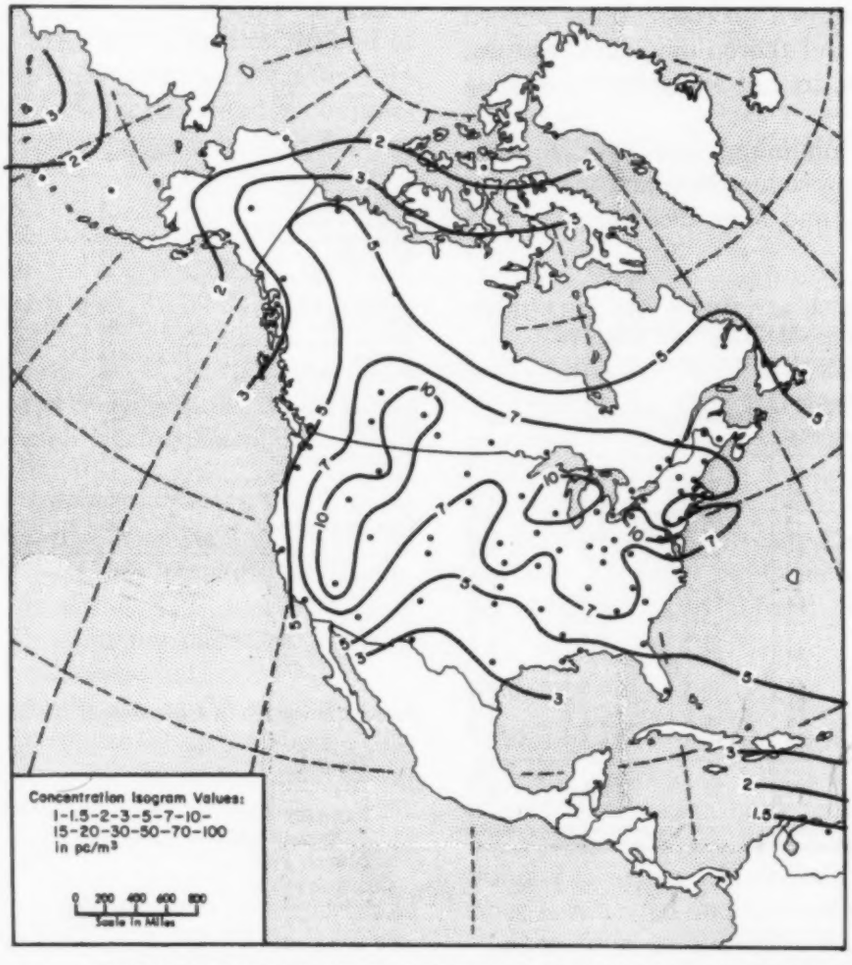

FIGURE 5.—AIRBORNE GROSS BETA CONCENTRATION ISOGRAMS FOR INTER-CALIBRATED NETWORKS, JULY 1963

SECTION II.—MILK AND FOOD

Milk Surveillance

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the U.S. population and contains most of the radionuclides occurring in the environment which have been identified as being biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to handle, is easily analyzed, and samples which are representative of milk consumption in any area can be readily obtained.

PASTEURIZED MILK NETWORK
July 1963

Division of Radiological Health and
Division of Environmental Engineering and
Food Protection, Public Health Service

The Public Health Service pasteurized milk radionuclide surveillance program had its origin in a raw milk monitoring network established by the Service in 1957. One of the primary objectives of this network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this earlier network led to the activation of a pasteurized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. Table 1 shows the growth of the network since its initiation in March 1960. More milk sampling points continued to be added until July 1962, when the total number of stations reached 62.

Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each of these stations. Composites of the samples are preserved with formaldehyde and are sent to the PHS Southwestern, Southeastern, or Northeastern Radiological Health Laboratories for analysis. Approximately 3–6 days after sample collection, any results from the gamma analyses which indicate concentrations of iodine–131 greater than 100 pc/liter are made available to the States for possible public health action. Complete analytical results are available 6 to 7 weeks after sample collection; publication in *Radiological Health Data* follows 3 to 4 months after sample collection.

Sampling and Compositing Procedures

The method of compositing specifies that each station's sample be composited of subsamples from each milk processing plant in proportion to the plant's sales in the community served. At most stations, the composited sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as could

TABLE 1.—DATE OF INCLUSION OF STATIONS IN PASTEURIZED MILK NETWORK

Sampling locations		Date of inclusion in PMN	Sampling locations		Date of inclusion in PMN	Sampling locations		Date of inclusion in PMN
Ala:	Montgomery	October 1961	Md:	Baltimore	August 1960	Okla:	Oklahoma City	July 1960
Alaska:	Palmer	March 1960	Mass:	Boston	June 1960	Ore:	Portland	April 1960
Ariz:	Phoenix	July 1960	Mich:	Detroit	July 1960	Pa:	Philadelphia	June 1960
Ark:	Little Rock	August 1960		Grand Rapids	July 1960		Pittsburgh	April 1960
Calif:	Sacramento	August 1960	Minn:	Minneapolis	August 1960	P. R.:	San Juan	July 1960
	San Francisco	June 1960	Miss:	Jackson	August 1960	R. I.:	Providence	June 1960
Colo:	Denver	March 1960	Mo:	Kansas City	April 1960	S. C.:	Charleston	August 1960
Conn:	Hartford	April 1960		St. Louis	August 1960	S. Dak:	Rapid City	January 1962
Del:	Wilmington	June 1960	Mont:	Helena	June 1960	Tenn:	Chattanooga	August 1960
D. C.:	Washington	July 1960	Nebr:	Omaha	August 1960		Memphis	September 1960
Fla:	Tampa	August 1960	Nev:	Las Vegas[1]	July 1962	Texas:	Austin	June 1960
Ga:	Atlanta	August 1960	N. H.:	Manchester	April 1960		Dallas	June 1960
Hawaii:	Honolulu	April 1960	N. J.:	Trenton	June 1960	Utah:	Salt Lake City	March 1960
Idaho:	Idaho Falls	March 1960	N. Mex:	Albuquerque	March 1960	Vt:	Burlington	April 1960
Ill:	Chicago	July 1960	N. Y.:	Buffalo	June 1960	Va:	Norfolk	July 1960
Ind:	Indianapolis	July 1960		New York	June 1960	Wash:	Seattle	April 1960
Iowa:	Des Moines	June 1960		Syracuse	April 1960		Spokane	May 1960
Kans:	Wichita	April 1960	N. C.:	Charlotte	June 1960	W. Va:	Charleston	April 1960
Ky:	Louisville	April 1960	N. Dak:	Minot	September 1961	Wis:	Milwaukee	July 1960
La:	New Orleans	July 1960	Ohio:	Cincinnati	August 1960	Wyo:	Laramie	April 1960
Maine:	Portland	June 1960		Cleveland	July 1960			

Date	Mar '60	Apr '60	May '60	Jun '60	Jul '60	Aug '60	Sept '60	Sept '61	Oct '61	Jan '62	Jul '62
Number of Stations Reporting	5	18	19	33	45	57	58	59	60	61	62

[1] Some Las Vegas milk data were published in *Radiological Health Data* prior to the station's inclusion into the Pasteurized Milk Network.

be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, sampling was done twice a week at nearly all stations and daily for short periods at selected stations. Since then, the sampling frequency has been reduced to once a week.

Analytical Errors in Radionuclide Measurements

Iodine–131, cesium–137, and barium–140 concentrations are determined by gamma scintillation spectroscopy,[1] while strontium–89 and strontium–90 concentrations are determined by radiochemical procedures. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation is relatively high. The variation is dependent upon the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclides, and the background count. For milk samples, counting times of 50 minutes for gamma spectroscopy and 30 to 50 minutes for low background beta determinations are used. The minimum detectable concentration is defined as the measured concentration at which the statistical two-standard-deviation analytical error is 100 percent (*1*). Accordingly, the minimum detectable concentrations in units of pc/liter are Sr^{89}, 5; Sr^{90}, 1; I^{131}, 10: Cs^{137}, 5; and Ba^{140}, 10.

Data Presentation

Summaries of the analyses for July 1963, (June 30–July 27, 1963) are presented in table 2. When a radionuclide is reported by a laboratory as being below the minimum detectable concentration, one-half of this value is used in calculating the monthly average. A similar procedure is used for the network average.

Although no data are presented on the stable potassium concentrations in milk, analysis has indicated that the usual range of concentrations is from 1.3 to 1.8 grams/liter. In July, for example, 9, 20, 11, 20, and 2 stations recorded respective monthly average potassium concentrations of 1.3, 1.4, 1.5, 1.6, and 1.7 grams/liter.

Figures 1 and 2 are isoconcentration maps showing the estimated radionuclide concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station. In order to show the distribution of the network's station versus radionuclide concentrations in milk, table 3 has been

[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium–140 analysis.

TABLE 2.—RADIOACTIVITY IN PASTEURIZED MILK, JULY 1963

[Average radioactivity concentrations in pc/liter]

Sampling locations		Calcium (g/liter)		Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140		Last Profile in RHD
		Second quarter	Avg. for month	Second quarter	Avg. for month	Second quarter	Avg. for month	Second quarter	Avg. for month	Second quarter	Avg. for month	Second quarter	Avg. for month	Month (1963)
Ala:	Montgomery	1.21	1.18	100	65	23	21	<10	<10	80	100	10	<10	Oct.
Alaska:	Palmer	1.17	1.17	35	45	15	19	<10	<10	55	110	<10	<10	Nov.
Ariz:	Phoenix	1.16	1.14	20	10	5	3	<10	<10	15	15	<10	<10	Sep.
Ark:	Little Rock	1.19	1.19	200	130	51	42	<10	<10	195	170	20	<10	Nov.
Calif:	Sacramento	1.21	1.19	115	20	19	11	<10	<10	90	50	<10	<10	Aug.
	San Francisco	1.22	1.18	175	30	27	12	<10	<10	110	75	<10	<10	Oct.
Colo:	Denver	1.23	1.19	35	60	14	26	<10	<10	70	135	<10	<10	Aug.
Conn:	Hartford	1.09	1.18	30	50	22	38	<10	<10	120	245	<10	<10	Aug.
Del:	Wilmington	1.07	1.12	65	40	28	34	<10	<10	130	165	<10	<10	Sep.
D. C:	Washington	1.16	1.07	90	70	24	22	<10	<10	120	140	<10	<10	Sep.
Fla:	Tampa	1.18	1.21	40	30	13	14	<10	<10	200	255	10	<10	Sep.
Ga:	Atlanta	1.21	1.22	145	110	33	36	<10	<10	155	260	10	<10	Oct.
Hawaii:	Honolulu	1.15	1.20	60	20	10	14	<10	<10	65	85	<10	<10	Nov.
Idaho:	Idaho Falls	1.20	1.18	80	125	22	49	<10	<10	110	225	<10	<10	Sep.
Ill:	Chicago	1.06	1.26	30	50	21	22	<10	<10	95	155	<10	<10	Oct.
Ind:	Indianapolis	1.10	1.18	55	50	29	28	<10	<10	100	120	<10	<10	Aug.
Iowa:	Des Moines	1.19	1.16	145	80	31	31	<10	<10	95	90	<10	<10	Sep.
Kans:	Wichita	1.19	1.17	90	65	21	32	<10	<10	85	95	<10	<10	Nov.
Ky:	Louisville	1.18	1.14	180	150	37	42	<10	<10	125	160	10	<10	Sep.
La:	New Orleans	1.23	1.22	175	125	45	41	10	<10	170	175	20	<10	Nov.
Maine:	Portland	1.07	1.22	30	65	25	42	<10	<10	120	310	<10	<10	Sep.
Md:	Baltimore	1.15	1.16	105	95	24	28	<10	<10	140	185	10	<10	Sep.
Mass:	Boston	1.10	1.21	35	80	28	54	<10	<10	150	285	<10	<10	Oct.
Mich:	Detroit	1.08	1.16	25	30	20	28	<10	<10	85	125	<10	<10	Aug.
	Grand Rapids	1.11	1.19	25	40	19	23	<10	<10	90	135	<10	<10	Sep.
Minn:	Minneapolis	1.20	1.17	80	110	28	38	<10	<10	130	200	<10	<10	Oct.
Miss:	Jackson	1.25	1.24	180	125	38	36	<10	<10	120	140	20	<10	Aug.
Mo:	Kansas City	1.21	1.15	155	80	32	28	<10	<10	100	85	<10	<10	Aug.
	St. Louis	1.19	1.18	110	80	27	30	<10	<10	95	100	<10	<10	Nov.
Mont:	Helena	1.19	1.17	70	135	21	44	<10	<10	105	295	<10	<10	Nov.
Nebr:	Omaha	1.21	1.20	100	85	27	33	<10	<10	90	125	<10	<10	Sep.
Nev:	Las Vegas	1.15	1.16	25	30	7	16	<10	<10	50	110	<10	<10	Oct.
N. H:	Manchester	1.12	1.26	40	60	28	50	<10	<10	170	380	<10	<10	Sep.
N. J:	Trenton	1.09	1.20	40	40	26	32	<10	<10	110	200	<10	<10	Aug.
N. Mex:	Albuquerque	1.16	1.16	40	35	10	12	<10	<10	35	50	<10	<10	Nov.
N. Y:	Buffalo	1.06	1.16	30	50	22	28	<10	<10	105	160	<10	<10	Aug.
	New York	1.09	1.15	40	80	24	44	<10	<10	110	195	<10	<10	Oct.
	Syracuse	1.08	1.22	35	60	24	34	<10	<10	105	165	<10	<10	Nov.
N. C:	Charlotte	1.25	1.20	135	125	34	35	<10	<10	130	185	10	<10	Nov.
N. Dak:	Minot	1.13	1.13	180	195	48	67	<10	<10	115	195	<10	<10	Sep.
Ohio:	Cincinnati	1.09	1.20	75	65	31	30	<10	<10	90	115	<10	<10	Aug.
	Cleveland	1.13	1.14	*40	60	24	28	<10	<10	100	125	<10	<10	Nov.
Okla:	Oklahoma City	1.17	1.13	130	85	28	24	<10	<10	120	115	10	<10	Oct.
Ore:	Portland	1.24	1.23	165	80	38	34	<10	<10	160	195	<10	<10	Aug.
Pa:	Philadelphia	1.08	1.18	55	60	29	30	<10	<10	130	165	<10	<10	Nov.
	Pittsburgh	1.10	1.20	55	90	27	33	<10	<10	125	195	<10	<10	Nov.
P. R:	San Juan	1.16	1.12	105	50	18	14	<10	<10	125	120	10	<10	Nov.
R. I:	Providence	1.08	1.19	45	60	27	45	<10	<10	125	255	<10	<10	Sep.
S. C:	Charleston	1.21	1.19	100	80	29	26	<10	<10	120	165	10	<10	Aug.
S. Dak:	Rapid City	0.92	0.93	105	160	34	56	<10	<10	125	210	<10	<10	Oct.
Tenn:	Chattanooga	1.22	1.23	195	170	40	48	<10	<10	160	260	10	<10	Oct.
	Memphis	1.22	1.18	160	120	38	34	<10	<10	110	135	10	<10	Sep.
Tex:	Austin	1.14	1.14	50	40	10	9	<10	<10	50	60	<10	<10	Oct.
	Dallas	1.16	1.19	120	60	25	20	<10	<10	100	80	10	<10	Aug.
Utah:	Salt Lake City	1.22	1.19	45	90	20	39	<10	<10	110	270	<10	<10	Nov.
Vt:	Burlington	1.09	1.16	30	70	24	43	<10	<10	110	235	<10	<10	Aug.
Va:	Norfolk	1.17	1.16	95	70	25	22	<10	<10	120	140	10	<10	Aug.
Wash:	Seattle	1.19	1.18	125	85	26	38	<10	<10	150	215	<10	<10	Oct.
	Spokane	1.26	1.22	105	95	27	38	<10	<10	125	185	<10	<10	Aug.
W. Va:	Charleston	1.17	1.14	145	125	37	36	<10	<10	115	145	10	<10	Oct.
Wis:	Milwaukee	1.10	1.26	30	40	20	25	<10	<10	90	135	<10	<10	Sep.
Wyo:	Laramie	1.20	1.16	70	80	24	38	<10	<10	120	140	<10	<10	Sep.
Network average		1.16	1.18	87	77	25.9	31.4	<10	<10	112	163	<10	<10	Nov.

* *Correction for October 1963 issue:* The second quarter strontium-89 average given in table 1 on page 500 was incorrectly reported as 49 pc/liter and should have been 40 pc/liter.

prepared using the monthly average data shown in table 2.

Figure 3 shows strontium–89, strontium–90, iodine–131, and cesium–137 maximum, average, and minimum monthly station values.

Iodine–131 has not appeared appreciably in milk during January through July 1963. The greatest monthly average concentration observed at any station during this period was 40 pc/liter. During May through July 1963 no concentrations greater than 10 pc/liter have been reported.

The network average strontium–89 concentrations in milk increased from 34 pc/liter in January to 106 pc/liter in June and then fell to 77 pc/liter

TABLE 3.—DISTRIBUTION OF SAMPLING STATIONS IN VARIOUS RANGES OF RADIONUCLIDE CONCENTRATIONS IN MILK, JULY 1963

Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations
<5–20	3	<1–9	2	<10	62	<5–45	1	<10	62
25–45	11	10–19	8			50–95	9		
50–70	19	20–29	16			100–145	20		
75–95	15	30–39	22			150–195	16		
100–120	3	40–49	10			200–245	7		
125–145	7	50–59	3			250–295	7		
150–170	3	60–69	1			300–345	1		
175–195	1					350–395	1		

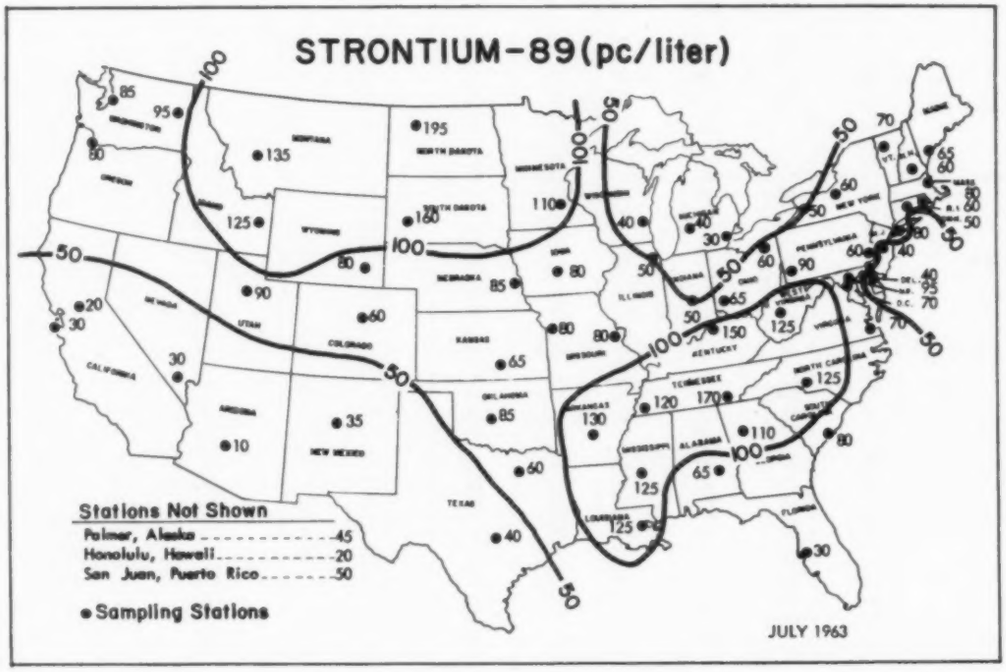

FIGURE 1.—STRONTIUM-89 CONCENTRATIONS IN PASTEURIZED MILK, JULY 1963

in July. Nationally, levels in the Mississippi valley have been high while levels in the Southwest have been low. In January and February, only the stations in the lower Mississippi valley reported monthly average strontium–89 concentrations as high as 150 to 270 pc/liter. In this same area in March levels ranged from 200 to 365 pc/liter. In April and May monthly average concentrations in the area remained at the 200 pc/liter level. Additionally, during these two months, levels of between 200 and 250 were observed along the west coast from Washington to California. During June all stations except three had average concentrations below 200 pc/liter. During July, 45 of the 62 stations reported strontium–89 concentrations of 25 to 95 pc/liter.

The network average strontium–90 concentration in milk increased from 15 pc/liter in January to the low thirties in June and July. During January and February all stations reported monthly average strontium–90 concentrations of between 10 and 36 pc/liter, except those in the Southwest, which reported less than 10 pc/liter. The lower Mississippi valley area had concentrations in the high thirties and low forties in March. By April this area was experiencing concentrations in the low fifties. During the months of May through July the lower Mississippi Valley area and the mid-South were reporting values in the forties. Average concentrations of 40–62 pc/liter began to appear in the northern part of the country from Idaho to Minnesota during these same three

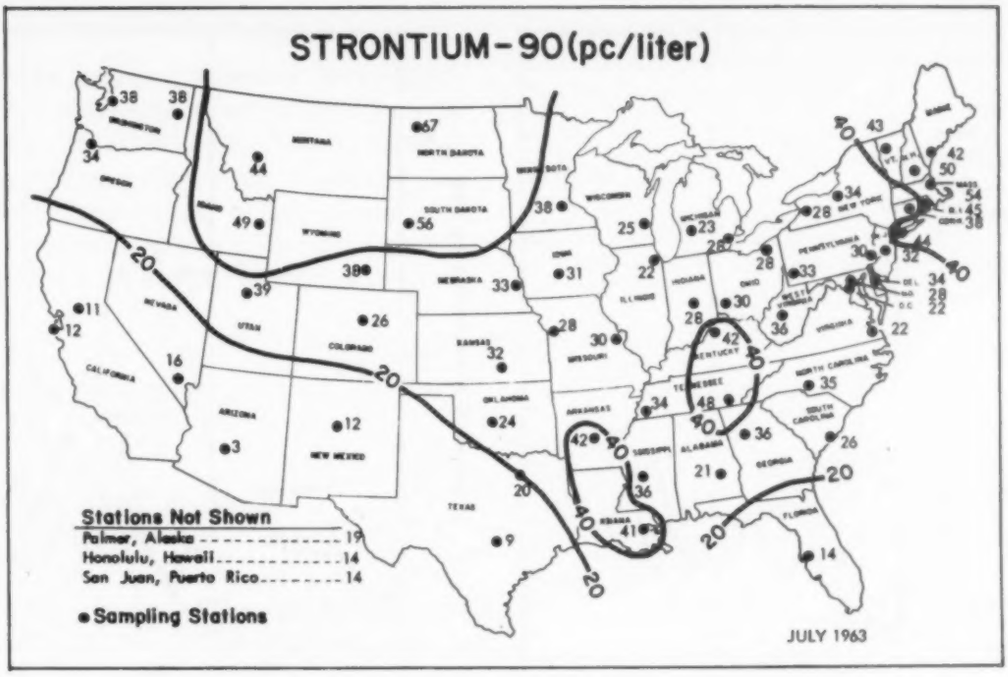

FIGURE 2.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK, JULY 1963

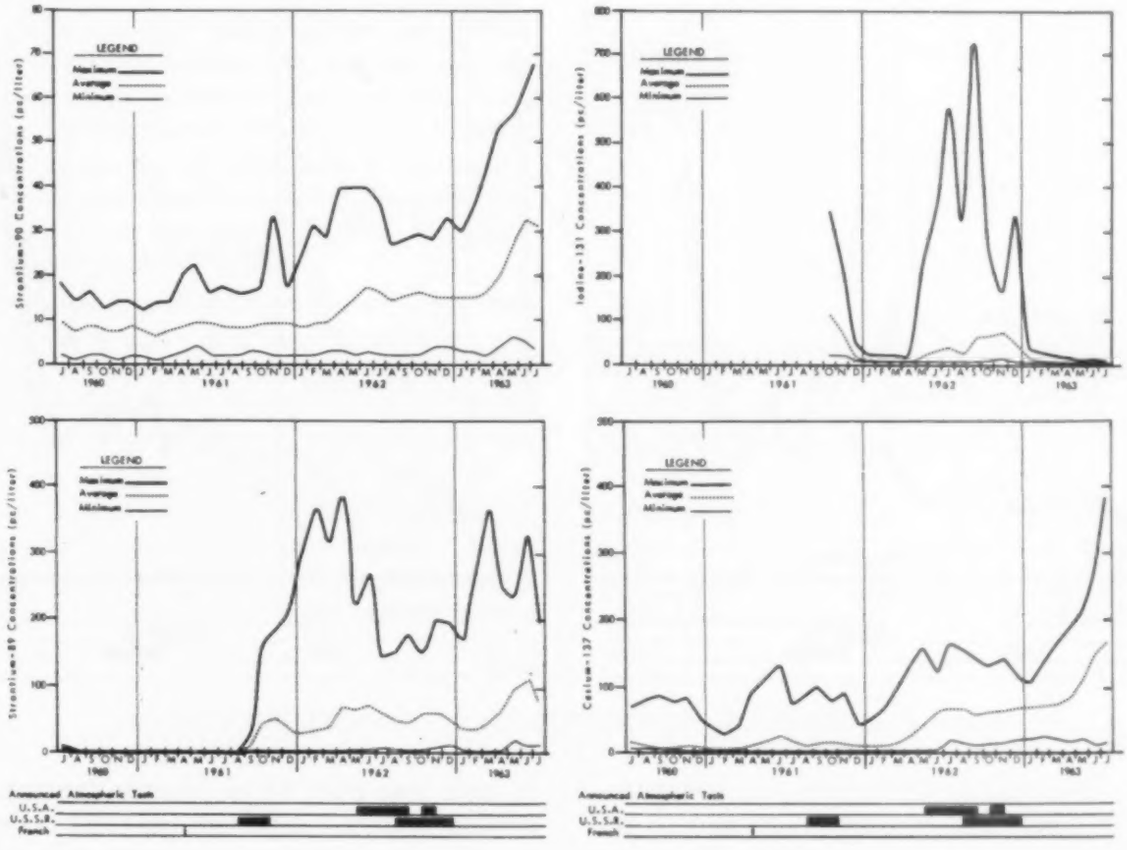

FIGURE 3.—PASTEURIZED MILK NETWORK MAXIMUM, AVERAGE, AND MINIMUM MONTHLY AVERAGES OF RADIONUCLIDE CONCENTRATIONS IN MILK

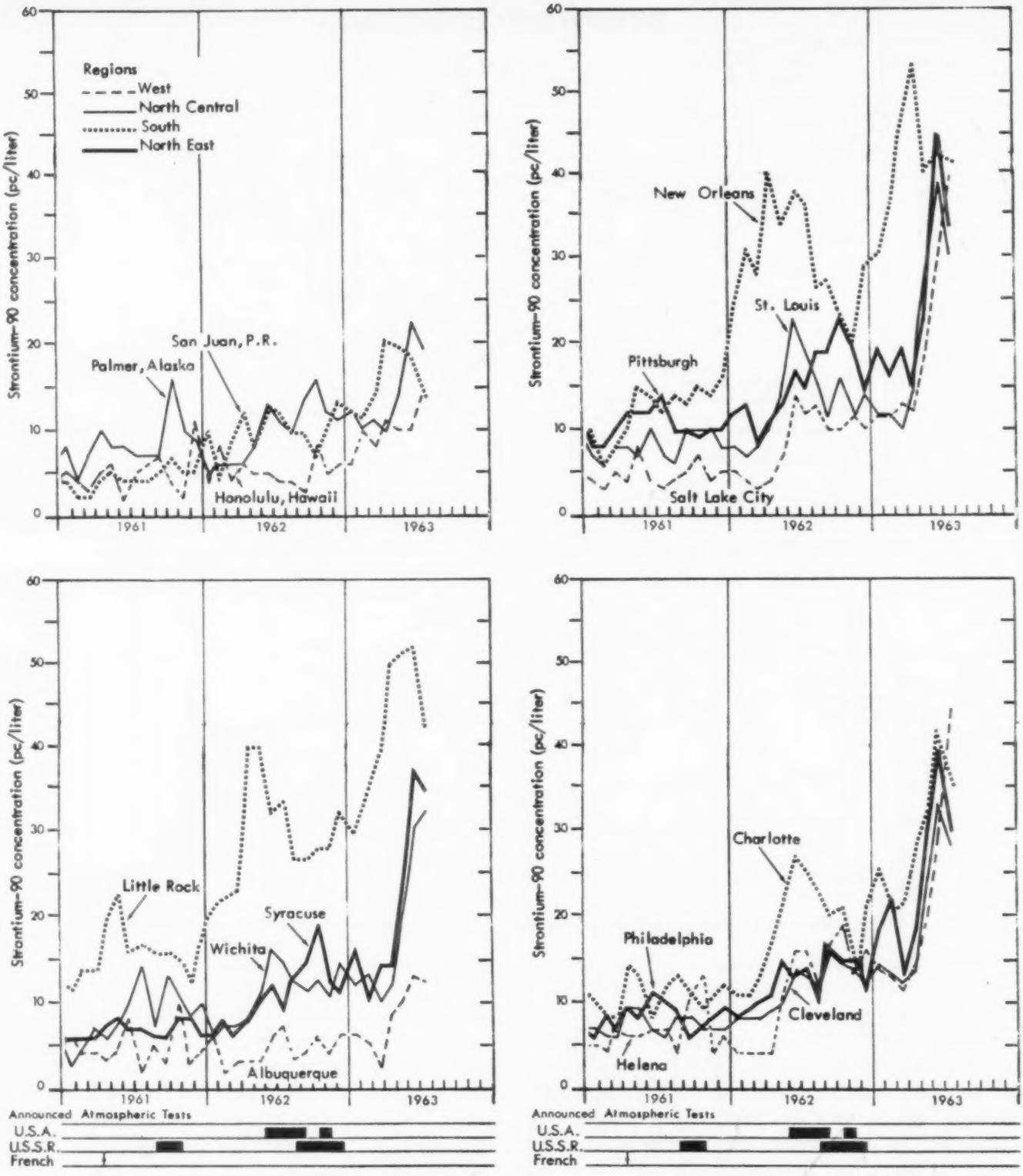

FIGURE 4.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK

months. During July 48 stations had strontium-90 monthly averages of between 20 and 50 pc/liter; 10 stations had less than 20 pc/liter; four stations had 50 or more pc/liter.

The network average cesium-137 concentration in milk rose from 65 pc/liter in January to 165 pc/liter in July. Although the total range of the monthly station averages observed in July was from 15 to 380 pc/liter, 46 stations reported values below 200 pc/liter.

Selected Monthly Strontium–90 Profiles

Continuing the practice followed in previous issues of *RHD*, the average monthly strontium–90 concentrations in pasteurized milk from 15 selected cities in the sampling program are presented (see figure 4). Each individual graph shows the strontium–90 concentrations in milk from one city in each of the four U.S. Bureau of Census regions. This method of selection permits graphic presentation of data for each city in the network at least twice a year.

REFERENCE

(*1*) Public Health Service: Pasteurized Milk Network, February 1963, *Radiological Health Data*, 4:291–6, Superintendent of Documents, Government Printing Office, Washington, 25, D.C. (June 1963).

INDIANA MILK NETWORK
July 1963

Bureau of Environmental Sanitation
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radiological analysis in September 1961. Indiana was geographically divided into five major milksheds, and one large dairy within each milkshed was selected as a sampling station (see figure 6).

The milk samples are routinely analyzed for iodine–131, cesium–137, barium–140, strontium–89, and strontium–90. Analyses for the gamma emitters iodine–131, cesium–137, and barium–140 are conducted on a weekly basis except when iodine–131 results exceed 100 pc/liter, at which time the frequency of sampling is increased. Strontium–89 and strontium–90 analyses are performed monthly on samples which are composited from weekly aliquots.

An ion exchange analytical procedure (*1*) is used for strontium–89 and strontium–90 analyses. A 512-channel pulse height analyzer and shielded 4 x 4-inch sodium iodide crystal are used for the gamma analysis of iodine–131, cesium–137, and barium–140.

The monthly averages of the data obtained for the individual sampling stations and the State averages are reported in table 5. The State average is an arithmetic average of the station values.

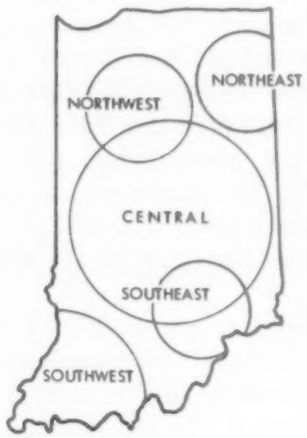

FIGURE 6.—INDIANA MILK SAMPLING LOCATIONS

TABLE 5.—RADIONUCLIDES IN INDIANA MILK, JULY 1963

[Concentrations in pc/liter]

Sampling location	Sr^{89}	Sr^{90}	I^{131}	Cs^{137}	Ba^{140}
Northeast	30	38	<10	120	<10
Southeast	60	60	<10	120	<10
Central	15	47	<10	115	<10
Southwest	30	57	<10	100	<10
Northwest	60	43	<10	145	<10
State average	40	49	<10	120	<10

REFERENCE

(*1*) Porter C., D. Cahill, R. Schneider, P. Robbins, W. Perry, and B. Kahn: Determination of Strontium–90 in Milk by an Ion Exchange Method, *Analytical Chemistry 33:* 1306–8 (September 1961).

MINNESOTA MILK NETWORK
September 1962–June 1963

Division of Environmental Sanitation
Minnesota Department of Health

In September 1958, the Minnesota State Department of Health initiated a pasteurized milk surveillance network to monitor milk for strontium–90. The network presently consists of eight sampling stations (see figure 7). In October 1961 the collection of "grab" milk samples for iodine–131 analyses was started at these stations.

A two-ounce sample is collected daily at each station and is incorporated into a monthly composite sample analyzed for strontium–90. Collection is made at the pasteurizing plants' bottling machines so that the sample is randomly representative of the milk produced in that milkshed. The most recent strontium–90 data are shown in table 6.

One-liter samples are collected weekly for iodine–131 analyses. The minimum detectable concentration of iodine–131 in milk is 10 pc/liter. The monthly average is an arithmetic average of all samples collected within a given month. These monthly averages are shown in table 7. A value of 5 pc/liter is used when averaging values which are reported as <10 pc/liter. If the calculated monthly average is below 10 pc/liter, then the monthly average is reported as <10 pc/liter.

FIGURE 7.—MINNESOTA MILK SAMPLING LOCATIONS

Analytical Procedure

Strontium–90 in milk is determined after ashing the evaporated residue from an 800-ml sample. Calcum and strontium are precipitated as oxalates from the ash. The separated oxalates are destroyed and the resulting solution scavenged with yttrium and barium. Yttrium–90 is allowed to ingrow and is then precipitated. This precipitate is converted to the oxalate, filtered and counted in a low-background anticoincidence counter.

Iodine–131 is determined by gamma spectrometry. One-liter samples of milk are counted for 100 minutes with a low-background sodium iodide crystal scintillator and multichannel analyzer. The counts in the iodine–131 photopeak which occur because of background and scatter from other gamma-emitting nuclides in milk are subtracted from the total. The value to be subtracted is empirically determined, and is based on the slope of the spectrum in this area and the magnitude of the counts in the channels adjacent to the photopeak.

TABLE 6.—STRONTIUM–90 IN MINNESOTA MILK, SEPTEMBER 1962—JUNE 1963

[Concentrations in pc/liter]

Sampling location	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Bemidji	21.8	21.2	25.0	21.0	23.8	24.0	29.0	34.0	45.0	61.0
Duluth	26.9	24.6	26.9	23.0	27.6	18.0	27.0	30.0	35.0	65.0
Fergus Falls	21.9	20.5	22.1	15.0	13.3	16.0	19.0	16.5	28.0	41.0
Little Falls	26.4	14.2	20.0	15.0	13.3	21.0	19.0	21.0	40.0	45.0
Mankato	12.2	12.4	36.3	11.4	14.7	8.2	12.3	15.5	12.0	41.0
Minneapolis	17.7	16.8	26.3	17.0	22.0	21.0	19.0	20.0	32.0	48.0
Rochester	12.7	14.8	[a]—	—	12.9	13.0	16.0	14.7	21.0	26.0
Worthington	16.4	—	16.4	—	13.2	15.0	16.0	13.3	16.0	33.0
Average	19.5	17.8	24.7	17.1	17.6	15.8	19.7	20.6	28.6	45.0

[a] Dash indicates no sample.

TABLE 7.—MONTHLY AVERAGE IODINE–131 IN MINNESOTA MILK, SEPTEMBER 1962—JUNE 1963

[Average concentrations in pc/liter]

Sampling location	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Bemidji	173	93	25	17	25	<10	<10	29	<10	11
Duluth	176	129	38	16	22	12	<10	43	28	15
Fergus Falls	144	99	46	<10	17	22	<10	24	12	<10
Little Falls	167	84	53	20	14	17	<10	18	19	<10
Mankato	107	69	44	18	16	16	<10	38	19	<10
Minneapolis	90	73	79	14	13	15	<10	30	17	<10
Rochester	66	87	[a]—	17	29	32	<10	30	10	<10
Worthington	138	141	74	16	31	<10	<10	35	20	<10
Average	133	97	51	15	21	16	<10	31	16	<10

[a] Dash indicates no sample.

The trend is upward for strontium–90 in Minnesota milk. The State average ranged between 15.8 and 24.7 pc/liter from September 1962 through April 1963. In May 1963 the average increased to 28.6 pc/liter and then rose to 45 pc/liter in June 1963. Bemidji and Duluth, the Northernmost stations, have consistently had higher strontium–90 concentrations in milk. The highest monthly average strontium–90 concentration occurred in Duluth in June 1963 when a value of 65 pc/liter was noted.

Recent coverage in *Radiological Health Data:*

Period	*Issue*
December 1960—April 1961	*October 1961*
October—December 1961 (iodine–131 data)	*March 1962*
May—December 1961 (strontium–90 data)	*August 1962*
March—September 1962	*April 1963*

NEW YORK MILK NETWORK
June 1963

Division of Environmental Health Services
State of New York Department of Health

Milk samples, collected routinely from six cities—Albany, Buffalo, Massena, Newburgh, New York City, and Syracuse (figure 8), are analyzed for their radionuclide content by the State of New York Department of Health. Pasteurized milk samples are collected daily and composited weekly for the determination of strontium–89, strontium–90, iodine–131, cesium–137, and barium–140 at all stations except Massena, where samples are composited bi-weekly and at New York City where one daily milk sample representing the total milk supply for that day is obtained and analyzed once per week. Samples are obtained from processing plants except at Albany, where the daily sample is obtained from a marketing point. During periods when cows are no longer on stored feed, the sample from Albany is analyzed daily for iodine–131. In the event that any city reports iodine–131 concentrations exceeding 100 pc/liter, increased surveillance is undertaken.

FIGURE 8.—NEW YORK MILK SAMPLING LOCATIONS

The matrix method (*1*) is used for the analysis of spectral data to determine the concentrations of gamma-emitting nuclides in milk. With this method, the individual nuclide contributions to

the gamma spectrum are separated by solution of simultaneous equations describing the spectral interferences.

The analytical procedure for strontium–89 and strontium–90 is based on ion exchange methods. Cations (including radiostrontium) are eluted from the ion exchange resin with sodium chloride solution, strontium isotopes are gathered by means of sodium carbonate, isolated by means of ethylenediaminetetraacetic acid (EDTA), and radiostrontium is counted with a low background beta counter having an 0.8 mg/cm^2 window. The strontium–90 portion is differentially estimated by a second count 40 hours later to determine the rate of growth of its daughter product yttrium–90. The monthly average radionuclide concentrations in milk are shown in table 8.

TABLE 8.—RADIONUCLIDES IN NEW YORK MILK, JUNE 1963

[Average concentrations in pc/liter]

Sampling location	Sr^{89}	Sr^{90}	I^{131}	Cs^{137}	$Ba\text{-}La^{140}$
Albany	75	21	<20	92	<20
Buffalo	48	16	<20	74	<20
Massena	76	16	<20	160	<20
Newburgh	81	30	<20	108	<20
New York City	113	31	<20	135	<20
Syracuse	91	27	<20	95	<20
Average	81	24	<20	111	<20

Note: $Ba\text{-}La^{140}$ refers to the sum of these two nuclides in equilibrium.

REFERENCE

(1) Kahn, B., et al.: *Rapid Methods for Estimating Fission Product Concentrations in Milk, Public Health Service Publication No. 999–R–2*, (March 1963). Single copies available on request from Public Inquiries Branch, PHS, U.S. Department of Health, Education and Welfare, Washington, D.C. 20201.

CANADIAN MILK NETWORK [1]
July 1963

Radiation Protection Division
Department of National Health and Welfare,
Ottawa, Canada

The Radiation Protection Division of the Department of National Health and Welfare began monitoring milk for strontium–90 in November 1955. At first, the analyses were carried out on samples of powdered milk obtained from processing plants. However, since January 1963 liquid whole milk has been analyzed instead. With this change, more representative samples can be obtained, and in addition it is possible to choose milk sampling locations (see figure 9) in the same areas as the air and precipitation stations. At present, the analyses include determinations of iodine–131, strontium–89 and cesium–137, as well as strontium–90.

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies, combined into weekly composites, and forwarded to the radiochemical laboratory in Ottawa for analysis. The contribution of each dairy to the composite sample is directed proportional to its volume of sales. In most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Iodine–131 is determined on a portion of each sample; the remaining portion is combined into monthly composites for the determination of strontium–90, strontium–89 and cesium–137.

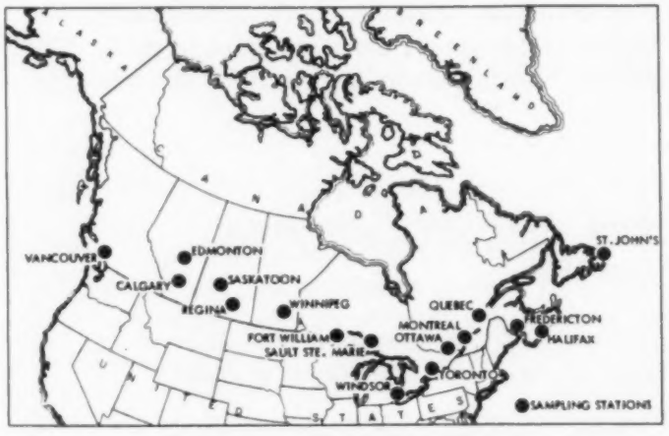

FIGURE 9.—CANADIAN MILK SAMPLING STATIONS

Analytical Methods

For the analysis of iodine–131, radiochemical methods (*1*) are used. Carrier iodide is added and the milk is then evaporated in the presence of sodium hydroxide and ashed. The iodide ion is oxidized to iodine and extracted with carbon tetrachloride, back-extracted in sulphite solution, and precipitated as silver iodide. The precipitate is counted in a low background beta counter and the iodine–131 determined by comparison with standard preparations.

[1] Data from *Radiation Protection Programs, Vol. 1, No. 8:* 19–21, Radiation Protection Division, Canadian Department of National Health and Welfare (August 1963).

For the analysis of radiostrontium, carrier strontium is added to a one-liter sample of milk, and the milk is then evaporated under infra-red lamps in a tray lined with a polyethylene sheet. The residue is ashed in a muffle furnace at 450°C, dissolved in dilute nitric acid, and strontium is separated on an ion-exchange column (*2*, *3*). The combined strontium–89 and strontium–90 are determined by counting in a low background beta counter. Strontium–90 is determined separately by extracting and counting the yttrium–90 daughter isotope, while strontium–89 is estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption and counter efficiency at all stages.

Cesium–137 is determined by gamma spectrometry using a scintillation crystal and a multichannel pulse height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray, constructed in the form of an inverted well to accommodate the 5 x 4 inch sodium iodide crystal detector. The sample is counted for 100 minutes and the gamma spectrum recorded. Estimates are made of the potassium–40 and cesium–137 content of the milk by comparison of the spectrum with standard preparations.

Sources of Error

In the iodine and strontium determinations, tests indicate that the statistical error (95 percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radioisotope in the milk because it depends only on the recovery of the "carrier". In the determination of cesium this factor is not involved.

The operational error must be combined with the counting error, which depends primarily on the concentration of the nuclide in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

The overall errors, estimated on the basis indicated above, are shown in table 9 (all errors are 2σ values, representing 95 percent confidence level).

Results

Table 10 presents the results of the measurements on strontium–89, strontium–90, cesium–137,

TABLE 9.—TOTAL PERCENTAGE ERROR FOR VARIOUS RADIONUCLIDE CONCENTRATIONS

Nuclide	Error for 10 pc/liter	Error for 50 pc/liter	Error for 100 pc/liter
Iodine-131	50	20	10
Strontium-90	15	10	10
Strontium-89	25	20	15
Cesium-137	60	25	10

TABLE 10.—RADIONUCLIDES IN CANADIAN WHOLE MILK, JULY 1963

[Radionuclide concentrations in pc/liter]

Station	Calcium (g/liter)	Strontium-89	Strontium-90	Iodine-131	Cesium-137
Calgary	1.37	214.9	74.1	3	309
Edmonton	1.29	143.3	53.1	1	278
Ft. William	1.34	127.7	52.9	6	296
Fredericton	1.35	132.7	54.1	2	322
Halifax	1.31	106.2	50.5	0	280
St. John's, Nfld.	1.27	155.9	75.1	2	382
Montreal	1.32	97.6	46.3	2	183
Ottawa	1.25	96.5	34.0	6	227
Quebec	1.28	121.0	43.9	1	229
Regina	1.30	134.4	46.3	4	180
Saskatoon	1.35	124.5	40.3	4	178
Sault Ste. Marie	1.25	104.7	40.2	3	231
Toronto	1.33	44.1	16.6	3	84
Vancouver	1.40	150.9	51.9	2	393
Windsor	1.32	44.0	16.9	6	69
Winnipeg	1.28	121.7	46.4	3	178
Average	1.31	120.0	46.4	3	239

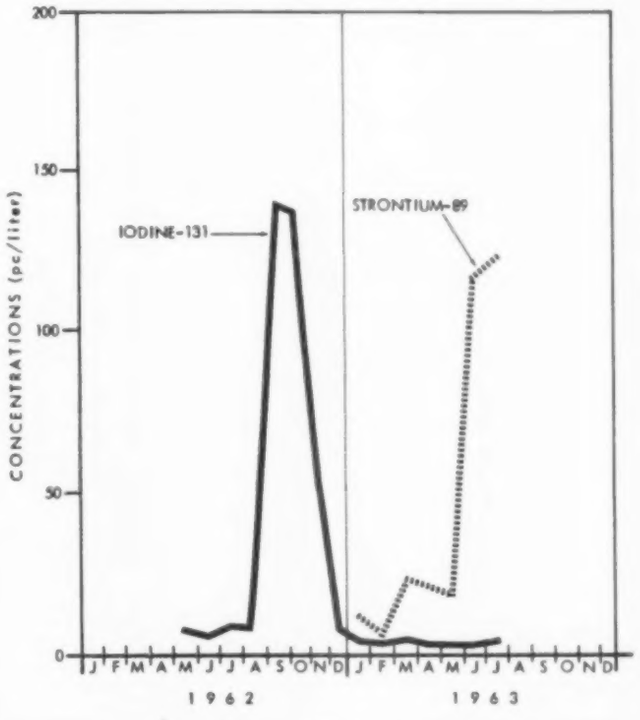

FIGURE 10.—IODINE–131 AND STRONTIUM–89 CONCENTRATIONS IN CANADIAN WHOLE MILK

iodine–131, and stable calcium in Canadian whole milk for July. Figures 10 and 11 show the time profiles of the network average of the radionuclides in Canadian whole milk.

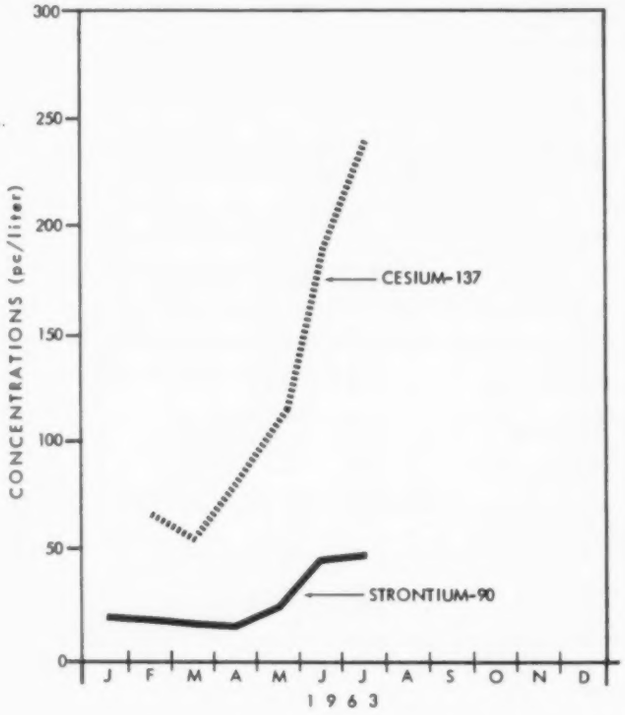

FIGURE 11.—STRONTIUM-90 AND CESIUM-137 CONCENTRATIONS IN CANADIAN WHOLE MILK

Discussion

It should be emphasized that the interpretation of fallout data in relation to health is a complex problem. In comparing the concentration levels in a particular medium with the so-called Maximum Permissible Concentrations (MPC's) as established by the International Commission on Radiological Protection (*4*), it is necessary to keep in mind that the MPC values refer to conditions of continuous exposure over a lifetime. Therefore, the average levels over an extended period such as one year represent a better basis for comparison than do individual levels at any specific time.

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(*3*) Mar, Peter G.: *Outline of Procedure for the Radiochemical Analysis of Dried Milk Powders for Strontium and Yttrium, RPD–5*, Radiation Protection Division, Department of National Health and Welfare, (June 1, 1960).

(*4*) International Commission on Radiological Protection: *Report of Committee II on Permissible Dose for Internal Radiation*, Pergamon Press, New York (1959).

ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN PASTEURIZED MILK
August 1962–July 1963

Utilization of the radionuclide concentration values reported by the Pasteurized Milk Network (*1*) for assessing that portion of an individual's or a population's radiation dose attributable to milk consumption is dependent on determining both the annual average concentrations of specific radionuclides of interest in milk and the average daily milk intake of an individual or a suitable sample of the population.

The data listed in table 1 are concerned with the first of these requirements, *i.e.*, annual average

TABLE 1.—ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN MILK

[Concentrations in pc/liter]

Sampling locations		Iodine-131		Strontium-89		Strontium-90	
		July 1962–June 1963	August 1962–July 1963	July 1962–June 1963	August 1962–July 1963	July 1962–June 1963	August 1962–July 1963
Ala:	Montgomery	17	17	65	66	17	18
Alaska:	Palmer	102	102	55	56	13	14
Ariz:	Phoenix	11	<10	20	19	4	4
Ark:	Little Rock	38	38	132	135	36	37
Calif:	Sacramento	12	11	41	42	7	8
	San Francisco	13	11	72	74	11	11
Colo:	Denver	17	13	32	30	13	13
Conn:	Hartford	21	20	26	28	14	16
Del:	Wilmington	31	31	40	42	19	20
D. C:	Washington	23	23	46	47	18	19
Fla:	Tampa	18	18	35	36	12	12
Ga:	Atlanta	24	23	86	91	22	23
Hawaii:	Honolulu	12	12	36	37	7	8
Idaho:	Idaho Falls	23	19	41	46	14	17
Ill:	Chicago	33	30	29	31	16	17
Ind:	Indianapolis	30	29	40	41	18	19
Iowa:	Des Moines	47	43	79	78	18	19
Kans:	Wichita	31	27	57	56	15	16
Ky:	Louisville	26	26	97	102	26	27
La:	New Orleans	28	27	148	150	34	34
Maine:	Portland	22	22	32	35	20	21
Md:	Baltimore	23	23	48	52	18	19
Mass:	Boston	21	21	35	39	22	25
Mich:	Detroit	35	34	28	28	16	17
	Grand Rapids	26	25	24	26	14	15
Minn:	Minneapolis	32	30	64	64	23	24
Miss:	Jackson	26	25	145	148	27	28
Mo:	Kansas	45	41	93	90	20	21
	St. Louis	27	24	61	61	17	18
Mont:	Helena	36	34	54	54	16	19
Nebr:	Omaha	44	39	67	65	18	20
Nev:	Las Vegas	14	<10	22	22	6	7
N. H:	Manchester	21	21	35	37	20	23
N. J:	Trenton	22	22	31	32	16	18
N. Mex:	Albuquerque	16	14	25	25	6	7
N. Y:	Buffalo	23	22	28	31	17	18
	New York	30	30	34	37	18	21
	Syracuse	25	24	31	34	16	18
N. C:	Charlotte	<10	<10	67	72	25	26
N. Dak:	Minot	38	35	79	83	30	33
Ohio:	Cincinnati	38	36	50	52	20	21
	Cleveland	30	30	31	33	16	18
Okla:	Oklahoma City	34	33	78	79	21	21
Ore:	Portland	24	23	107	111	20	21
Pa:	Philadelphia	29	28	35	38	19	20
	Pittsburgh	38	37	40	44	21	22
P. R:	San Juan[1]	15	15	86	87	13	13
R. I:	Providence	22	22	32	35	18	21
S. C:	Charleston	20	19	70	72	23	23
S. Dak:	Rapid City	39	35	67	71	21	24
Tenn:	Chattanooga	20	20	108	116	27	28
	Memphis	27	27	102	105	26	26
Tex:	Austin	30	30	37	39	8	8
	Dallas	49	49	91	92	19	19
Utah:	Salt Lake City	88	43	38	39	14	16
Vt:	Burlington	23	23	34	37	17	19
Va:	Norfolk	17	17	56	56	21	21
Wash:	Seattle	26	23	74	77	18	20
	Spokane	26	20	50	53	17	19
W. Va:	Charleston	17	16	74	76	25	26
Wis:	Milwaukee	38	36	27	29	13	14
Wyo:	Laramie	51	23	66	62	16	18

[1] Average is for 48 weeks (No sample was received in November 1962).

concentrations of strontium–89, strontium–90 and iodine–131 in one liter of pasteurized milk. Limited data are available for estimating the average daily milk intake (on a volume basis) for specific age groups in the U.S. population (*2*, *3*).

Employing an assumption, that the average daily milk consumption of an individual in a population group is one liter, permits comparisons to be made between the daily rates of intake of the above radionuclides from the milk component of the diet and the Federal Radiation Council's action ranges of transient daily rates of intake (*4*). The upper limits of Range II correspond to the Radiation Protection Guide (RPG) for iodine–131 and one-third of the RPG for radioactive strontium. The Guides are, for administrative reasons, expressed as a yearly radiation dose, but are based on lifetime exposure (*5*)[1]. The FRC emphasizes that the annual acceptable risk or exposure dose is not a dividing line between safety and danger in actual radiation situations (*6*).

Table 1, consisting of annual averages of radionuclide concentrations in milk, is based on the PHS Pasteurized Milk Network monthly averages of these radionuclides. To obtain the annual average daily intake (pc/day) of radionuclides from milk, the annual average concentration values, (pc/liter) in table 1 must be multiplied by the annual average daily consumption (liters/day) of milk (*3*, *4*).

The data in table 1 are calculated as follows: (a) results from all samples collected in each week (Sunday through Saturday) are averaged, (b) the averages for all weeks ending in 12 consecutive months are averaged to obtain the annual average.

Monthly variations of radionuclide concentrations in milk are due to a number of combined causes. The moving yearly average (table 1) obtained by updating the previous twelve-month average by one month, shows variations averaged over the year and tends to minimize purely seasonal variations. This method therefore shows trends over a considerable period of time.

[1] Upper limit of Range II corresponds to a dose of one-third of the annual RPG in the case of radioactive strontium.

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(*1*) Public Health Service: Pasteurized Milk Network, *Radiological Health Data*, *4*:551–7, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., (November 1963).

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(*3*) Bureau of the Census and Public Health Service: Consumption of Selected Food Items in U.S. Households, July 1962, *Radiological Health Data*, *4*:124–7, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., (March 1963).

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SECTION III.—WATER

Radioactivity in Raw Surface Waters

NATIONAL WATER QUALITY NETWORK
May 1963

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been under surveillance by the Public Health Service National Water Quality Network since its initiation in 1957. Beginning with the establishment of 50 sampling points, this network has expanded to 127 stations as of October 1963 (figure 1), operated jointly with State, Federal and local agencies and industry. Surface waters of all major river basins of the United States are sampled and analyzed physically, chemically, biologically and radiologically. These data can be used for evaluating sources of radioactivity which may affect specific domestic, commercial, and recreational uses of surface water. Further, the Network provides background information necessary for recognizing pollution and water quality trends and for determining levels of radioactivity to which the population may be subjected. Data assembled through the Network are published in an annual compilation (*1–6*).

FIGURE 1.—TOTAL BETA ACTIVITY (pc/liter) IN SURFACE WATER AT NATIONAL WATER QUALITY NETWORK SAMPLING STATIONS, MAY 1963

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS, MAY 1963

[Average concentrations in pc/liter]

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River: Pittsburgh, Pa	7	15	22	0	0	0
Animas River: Cedar Hill, N. Mex	72	42	114	5	1	6
Apalachicola River: Chattahoochee, Fla	35	28	63	<1	0	<1
Arkansas River						
Coolidge, Kans	11	98	109	<1	25	25
Ponca City, Okla	68	84	152	1	2	3
Fort Smith, Ark	89	64	153	10	1	11
Pendleton Ferry, Ark	57	60	117	3	4	7
Bear River: Preston, Idaho	0	24	24	0	0	0
Big Horn River: Hardin, Mont	396	53	449	56	8	64
Big Sioux River: Sioux Falls, S. Dak	67	115	182	2	3	5
Chattahoochee River						
Atlanta, Ga	32	14	46	2	0	2
Columbus, Ga	38	28	66	1	0	1
Lanett, Ala	3	14	17	0	0	0
Clearwater River: Lewiston, Idaho	8	14	22	0	0	0
Clinch River						
Clinton, Tenn	10	16	26	0	<1	<1
Kingston, Tenn	47	152	199	1	1	2
Colorado River						
Loma, Colo	70	54	124	5	5	10
Page, Ariz	2	60	62	0	6	6
Boulder City, Nev	5	61	66	0	9	9
Parker Dam, Calif-Ariz	0	15	15	1	7	8
Yuma, Ariz	2	60	62	0	5	5
Columbia River						
Northport, Wash	6	17	23	0	0	0
Wenatchee, Wash	6	16	22	0	1	1
Pasco, Wash	74	286	360	1	1	2
McNary Dam, Ore	40	132	172	0	<1	<1
Bonneville, Ore	76	126	202	0	1	1
Clatskanie, Ore	47	97	144	0	0	0
Cumberland River: Clarksville, Tenn	6	14	20	0	0	0
Connecticut River						
Wilder, Vt	9	28	37	0	0	0
Northfield, Mass	13	25	38	0	0	0
Enfield Dam, Conn	12	19	31	0	0	0
Cuyahoga River: Cleveland, Ohio	16	66	82	<1	1	1
Delaware River						
Martins Creek, Pa	7	22	29	0	0	0
Trenton, N. J	42	23	65	0	1	1
Philadelphia, Pa	19	30	49	1	1	2
Escambia River: Century, Fla	16	15	31	0	0	0
Great Lakes						
Duluth, Minn	7	17	24	0	0	0
Sault Ste, Marie, Mich	2	7	9	0	0	0
Milwaukee, Wisc	2	18	20	0	1	1
Gary, Ind	8	19	27	0	0	0
Port Huron, Mich	9	18	27	0	0	0
Detroit, Mich	8	19	27	0	0	0
Buffalo, N. Y	14	23	37	0	1	1
Green River: Dutch John, Utah	0	38	38	0	3	3
Hudson River: Poughkeepsie, N. Y	10	22	32	0	0	0
Illinois River: Grafton, Ill	43	74	117	2	0	2
Kanawha River: Winfield Dam, W. Va	9	18	27	0	0	0
Klamath River: Keno, Ore	13	31	44	0	0	0
Kansas River: De Soto, Kans	255	97	352	4	1	5
Maumee River: Toledo, Ohio	29	77	106	<1	1	1
Little Miami River: Cincinnati, Ohio	54	70	124	1	0	1
Merrimack River: Lowell, Mass	13	35	48	0	0	0
Mississippi River						
St. Paul, Minn	31	69	100	0	2	2
Dubuque, Iowa	30	51	81	1	1	2
Burlington, Iowa	45	49	94	0	0	0
E. St. Louis, Ill	134	68	202	9	2	11
Cape Girardeau, Mo	233	65	298	6	4	10
W. Memphis, Ark	142	39	181	3	0	3
Vicksburg, Miss	98	45	143	1	1	2
Delta, La	77	39	116	7	1	8
New Orleans, La	20	38	58	1	0	1
Missouri River						
Williston, N. Dak	24	57	81	2	4	6
Yankton, S. Dak	8	37	45	0	6	6
Mo. River—Cont.						
Omaha, Nebr	152	39	191	5	2	7
St. Joseph, Mo	158	54	212	5	2	7
Kansas City, Kans	318	56	374	32	8	40
Missouri City, Mo	194	44	238	21	2	23
St. Louis, Mo	524	66	590	35	2	37
Monongahela River: Pittsburgh, Pa	0	49	49	0	1	1
North Platte River: Henry, Nebr	29	63	92	<1	17	17
Ohio River						
Addison, Ohio	2	19	21	0	0	0
Huntington, W. Va	13	18	31	0	1	1
Cincinnati, Ohio	19	32	51	0	0	0
Louisville, Ky	17	30	47	0	0	0
Evansville, Ind	24	32	56	1	1	2
Cairo, Ill	34	40	74	5	<1	5
Ouachita River: Bastrop, La	71	68	139	2	1	3
Pend Oreille River: Idaho	8	7	15	0	0	0
Platte River: Plattsmouth, Nebr	115	75	190	4	3	7
Potomac River						
Williamsport, Md	8	23	31	0	0	0
Great Falls, Md	7	21	28	0	0	0
Rainy River						
Baudette, Minn	32	59	91	1	0	1
International Fls, Minn	14	48	62	0	0	0
Red River, North: Grand Forks, N. Dak	19	82	101	1	3	4
Red River, South						
Denison, Tex	16	47	63	1	0	1
Index, Ark	87	61	148	2	1	3
Bossier City, La	125	52	177	3	0	3
Alexandria, La	74	48	122	4	1	5
Rio Grande River						
Alamosa, Colo	16	26	42	0	2	2
El Paso, Tex	12	32	44	0	5	5
Laredo, Tex	256	68	324	14	1	15
Brownsville, Tex	17	31	48	0	3	3
Roanoke River: John H. Kerr Resr. & Dam Va	12	14	26	1	0	1
Sabine River: Ruliff, Tex	47	52	99	2	1	3
Sacramento River: Courtland, Calif	13	8	21	0	0	0
San Juan River: Shiprock, N. Mex	85	35	120	16	4	20
St. Lawrence River: Massena, N. Y	17	26	43	0	1	1
Schuylkill River: Philadelphia, Pa	10	29	39	0	0	0
Savannah River: North Augusta, Ga	31	19	50	0	0	0
Shenandoah River: Berryville, Va	19	14	33	0	0	0
Ship Creek: Anchorage, Alaska	13	22	35	0	0	0
Snake River:						
Ice Harbor Dam, Wash	6	18	24	0	1	1
Wawawai, Wash	21	14	35	0	1	1
Payette, Idaho	20	25	45	0	1	1
South Platte River: Julesburg, Colo	19	95	114	<1	32	32
Spokane River: Post Falls, Idaho	15	14	29	1	0	1
Susquehanna River						
Sayre, Pa	14	14	28	0	0	0
Conowingo, Md	5	14	19	0	0	0
Tennessee River						
Lenoir City, Tenn	20	28	48	<1	0	<1
Chattanooga, Tenn	76	52	128	2	0	2
Bridgeport, Ala	12	23	35	0	0	0
Pickwick Landing, Tenn	21	29	50	0	<1	<1
Tombigbee River: Columbus, Miss	69	24	93	1	1	2
Truckee River: Farad, Calif	14	14	28	0	0	0
Verdigris River: Nowata, Okla	6	51	57	0	0	0
Wabash River: New Harmony, Ind	96	58	154	4	1	5
Willamette River: Portland, Ore	0	6	6	0	0	0
Yakima River: Richland, Wash	2	5	7	0	0	0
Maximum	524	286	590	56	32	64
Minimum	0	5	6	0	0	0

[a] These data are preliminary; reanalysis of some samples may be made and additional analysis not completed at the time of the report may become available. For final data, one should consult the Network's *Annual Compilation of Data* (6).

A one-liter "grab" sample is collected weekly by personnel of the participating agencies and shipped to the Public Health Service laboratory in Cincinnati for analysis. Determinations of gross alpha and gross beta radioactivity in the suspended and dissolved solids and of strontium–90 activity in the total solids are carried out on frequency schedules based on need.

Gross beta activity in each weekly sample was determined until essentially background levels were reached in January 1960. Thereafter, gross beta determinations were made on monthly composites of the weekly samples received from all stations, except those located downstream from known potential sources of radioactive waste and those from all newly established Network stations. (Weekly alpha and beta measurements are scheduled routinely during the first year of operation at newly established stations.) On September 1, 1961, weekly determinations of gross beta activity again were instituted to permit rapid detection of activity due to fallout from renewed weapons testing. This practice was continued until the end of October 1962, when samples for gross beta analysis were again composited monthly. Gross alpha determinations were made once monthly except where variable or high values observed during the first year indicated the need for more frequent measurement.

Normally, samples are counted at the Network laboratory within two weeks following collection or within one week after compositing. The decay of activity is followed on each sample that shows unusually high activity during the first analysis. Also, if a recount indicates that the original analysis was questionable, values based on recounting are recorded. All results are reported for the time of counting and are not corrected by extrapolation to the time of collection.

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*7*). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 microns. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known count rate if the instrument is in proper calibration, are used for daily checking of the counters.

Since the fourth quarter of 1958, strontium–90 analyses have been made on three-month composites of aliquots from weekly samples. Until the fourth quarter of 1961, the method used for determining strontium–90 was that described in the aforementioned reference (*7*). Tributylphosphate was used to extract ingrown yttrium–90 from the purified, coprecipitated strontium–90. Since that time a modification of a procedure described by Harley has been used (*8*). The yttrium–90, together with an yttrium carrier, is precipitated at pH 8.5; the precipitate is washed, redissolved, and reprecipitated as yttrium oxalate and the latter is washed and counted in a low-background, anticoincidence, end-window proportional counter.

Table 1 presents May 1963 results of alpha and beta analyses of U.S. raw surface waters. These data are preliminary; reanalysis of some samples may be made and additional analyses, not completed at the time of this report, may become available. For final data one should consult the Network's *Annual Compilation of Data* (*6*). The figures for gross alpha and gross beta radioactivity represent either determinations made on composite samples or means of weekly determinations where composites were not made.

In order to obtain a geographical perspective of the radioactivity in surface water, the numbers alongside the various stations in figure 1 give the total beta activity in suspended-plus-dissolved solids in raw water collected at that station. Network results for the years 1957–1962 have been summarized by Weaver *et al* (*9*).

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RADIOACTIVITY IN MINNESOTA SURFACE WATER
December 1962–June 1963

Division of Environmental Sanitation,
Minnesota Department of Health

The analysis of various Minnesota waters for radioactivity concentration was initiated in 1956 as part of the Minnesota Water Pollution Control Program. This program was expanded in 1958 to include most of the municipal surface water supplies in the State as well as selected lakes throughout the State.

As many as 25 surface streams and lakes involving 74 stations have been sampled, but 7 surface streams and lakes involving 9 stations are now sampled routinely (see figure 2). "Grab" samples of raw treated water are collected weekly at each station with the exception of the Crookston Interrational Falls, and St. Cloud stations, where monthly samples are collected.

The samples are forwarded to the Division's Laboratory where they are analyzed for gross beta activity. A 250-ml sample of water is evaporated at 75°C. from a planchet. The solid residue (suspended plus dissolved solids) is fixed by adding lucite in acetone. Afterwards, this sample is counted with either an internal proportional counter or a thin end window proportional counter. Counter standardization is accomplished by adding known amounts of thallium–204 standard to solutions containing the normal range of solids.

FIGURE 2.—SURFACE WATER SAMPLING LOCATIONS

Table 2 shows the monthly average gross beta activity in Minnesota surface water from December 1962 through June 1963. The minimum de-

TABLE 2.—TOTAL BETA CONCENTRATION IN MINNESOTA RAW AND TREATED WATER FROM SURFACE SUPPLIES, DECEMBER 1962—JUNE 1963

[Monthly average concentrations in pc/liter]

Town (Water source)	Type of water	Dec	Jan	Feb	Mar	Apr	May	Jun
Crookston, (Red Lake River)	Raw	[a]—	—	—	15	51	120	75
	Treated	—	—	—	15	36	72	75
East Grand Forks, (Red Lake River)	Raw	30	20	21	40	164	83	100
	Treated	21	15	20	28	82	45	45
Eveleth, (St. Mary's Lake)	Raw	20	21	34	29	28	51	90
	Treated	17	32	24	33	36	55	41
Fairmont, (Budd Lake)	Raw	32	20	19	56	56	50	54
	Treated	15	16	32	29	30	39	19
Hallock, (Two Rivers South Fork)	Raw	53	36	49	61	164	117	130
	Treated	22	20	24	33	97	48	44
International Falls, (Rainy River)	Raw	—	46	—	25	42	70	41
	Treated	—	15	—	25	40	75	16
Minneapolis, (Tap Water)	Raw	—	—	—	—	—	—	—
	Treated	—	16	16	17	51	31	29
St. Cloud, (Mississippi River)	Raw	—	15	—	15	120	107	63
	Treated	—	15	—	15	39	35	51
St. Paul, (Vadnais Chain of Lakes)	Raw	30	24	24	50	57	63	83
	Treated	21	57	19	32	45	28	63

[a] Dash indicates no analysis performed.

tectable level is a convenient low value not normally exceeded by one standard deviation; this is at present 15 pc/liter. In averaging, the value 15 pc/liter is used for samples having this concentration or less. The two-standard-deviation counting error for a majority of analyses of individual samples ranges from 19 to 25 pc/liter.

The data obtained on gross beta activity in Minnesota surface waters show a variation of concentrations, with no readily apparent trends. Variation in precipitation and flow rates of streams could contribute to this variation. Monthly averages of gross beta radioactivity in Minnesota raw surface waters ranged from 15 to 164 pc/liter. Individual samples had concentrations that ranged from <15 to 280 pc/liter.

SECTION IV.—OTHER DATA

Strontium-90 in Human Vertebrae, March 1962—March 1963[1]

Joseph Rivera[2]

In *HASL–127* (*1*), data were presented on the strontium–90 content of human vertebrae collected from March 1961 to February 1962 at New York City, Chicago and San Francisco.

This report contains similar data on the results of analyses of samples collected from March 1962 to March 1963. The purpose of these studies is to establish more quantitatively the relation between strontium–90 and calcium levels in the diet and in bone, and also to continue the documentation of strontium–90 levels in human bone in this country.

During the period March 1962 to March 1963, 402 bone specimens were obtained. Of these, 215 were considered suitable to be analyzed singly or as part of composite samples. Analyses were performed on 165 vertebrae and 25 other samples which were part of the quality control program.

Results of the analyses are presented in table 1. A summary of previous results obtained in the HASL bone studies is given in table 2.

From tables 1 and 2 it is apparent that the levels strontium–90 in the bones obtained in 1963 were generally higher than those obtained in 1962. The variation of levels with age is similar to that seen in 1962 and in previous years by Kulp and Schulert (*2*) and Bryant and Loutit (*3*).

As was expected from the diet levels (*4*), highest strontium–90 levels were found in bones from New York City, lowest values were seen in bones from San Francisco, and intermediate values were generally found in bones obtained in Chicago.

Infants (0–1 year)

From measurements of the stable strontium concentrations in the diet and bones of children from 0 to 1 year old, the bone/diet observed ratios were 0.31, using data from New York City and San Francisco (*5*). The predicted values of the Sr^{90}/Ca ratio of the bones of six-month-old children in 1963 should, therefore, be approximately 0.31 times the estimated Sr^{90}/Ca ratio of their diet. This is an approximation, since no account has been taken of the degree to which the infants are in equilibrium with their diet.

An estimate of how close the bone levels are in equilibrium with the diet as far as strontium is concerned may be made by comparing the specific activity (pc Sr^{90}/mg Sr) of bone with that of the diet. In New York City, the calculated specific activity of the bones of six-month-old children was 20 pc/mg, while the diet had a specific activity of 24 pc/mg. In San Francisco the values were 3.2 pc/mg in bone and 5.3 pc/mg in the diet. From these values one may conclude that the New York City infants had 80 percent of their skeletons formed with a Sr^{90}/Ca ratio of 0.31 times the Sr^{90}/Ca ratio of their diet, and 20 percent of their

[1] Summarized from *Fallout Program Quarterly Summary Report, HASL–138*:239–48, Office of Technical Services, Department of Commerce, Washington 25, D.C. (July 1, 1963), price $3.50.

[2] Mr. Rivera is a physicist on the Staff of the Environmental Studies Division, Health and Safety Laboratory, U.S. Atomic Energy Commission, 376 Hudson Street, New York 14, New York.

TABLE 1.—STRONTIUM-90 IN HUMAN VERTEBRAE, MARCH 1962—MARCH 1963

[Concentrations in pc/g Ca]

Age at death (years)	New York		Chicago		San Francisco	
	Number of samples[a]	Average[b]	Number of samples[a]	Average[b]	Number of samples[a]	Average[b]
0–1	16	3.81±1.26	0		26	1.07±0.34
1–2	8	3.29±1.17	1	2.32	2	1.27±0.50
2–3	4	2.68±0.90	0		6	1.53±0.63
3–4	9	2.62±0.68	1	0.68	5	1.18±0.36
4–5	3	1.94±0.25	1	1.06	4	1.15±0.84
5–6	0		2	1.68±0.44	3	0.63±0.17
6–7	1	1.81	1	1.49	3	1.10±0.24
7–8	1	1.65	0		3	0.92±0.17
8–9	4	1.57±0.23	0		0	
9–10	2	1.69±0.31	1	1.43	1	0.51
10–12	0		2	0.81	1	0.41
12–14	4	1.81±0.74	2	1.08±0.49	1	1.0
14–16	2	1.54±0.07	2	1.50±0.39	3	1.00±0.19
16–18	6	2.36±1.63	1	1.51	1	0.97
18–20	6	1.73±0.40	0		3	0.92±0.36
20–40	6	1.01±0.06	18	0.81±0.42	5	0.94±0.29
40–60	3	0.61±0.04	26	0.69±0.24	3	0.45±0.10
over 60	5	1.04±0.04	6	1.62±0.19	1	0.59

[a] Individual sample values may be found in *HASL-138* (see footnote 1, page 570).
[b] ± values indicate one standard deviation of samples from the mean values.

TABLE 2.—STRONTIUM-90 IN HUMAN VERTEBRAE, MARCH 1961—MARCH 1962

[Concentration in pc/g Ca]

Age at death (years)	New York		Chicago		San Francisco	
	Number of samples	Average[a]	Number of samples	Average[a]	Number of samples	Average[a]
0–1	8	3.43±1.50	1	1.40	10	0.49±0.09
1–2	5	2.67±0.26			3	0.79±0.52
2–3	2	2.34±0.32				
3–4	5	2.05±0.82	1	2.26	4	1.33±0.19
4–5	4	1.74±0.54	3	2.08±0.18	2	2.15±1.63
5–6	1	1.51				
6–7	5	1.37±0.46				
7–8	3	1.62±0.49			2	0.52±0.10
8–9					1	0.78
9–10	2	1.20±0.44			4	1.18±0.04
10–12	2	1.55±0.64	2	1.37±0.45	2	0.62±0.04
12–14	2	0.62±0.64	2	1.03	1	0.67
14–16	3	1.16±0.34	2	1.37±0.04	1	1.68
16–18	6	1.44±0.28	1	1.36		
18–20	11	1.03±0.20	3	0.48±0.33		
20–40	16	1.05±0.51	10	0.57	15	0.50±0.13
40–60	10	0.63±0.05	20	0.44±0.04	15	0.46±0.06
over 60	5	0.69	9	0.76	15	0.50±0.09

[a] Individual sample values may be found in *HASL-138* (see footnote 1, page 570).

skeletons with a Sr^{90}/Ca ratio proportional to the Sr^{90}/Ca ratio of the diet of their mothers. In San Francisco these relative fractions were 60 and 40 percent. Using the currently accepted proportionality factor of 0.1 for the fetal bone-mother's diet observed ratio, and the Sr^{90}/Ca ratio of the mother's diet during the period of gestation, a more refined prediction of the Sr^{90}/Ca ratios in infant's bones can be made. These predictions and corresponding observed values are given in table 3.

Children (1.5–4.5 years)

Calculation of bone strontium-90 levels at different ages may be accomplished by considering the following equation, which is a simplified version of that given by Kulp:

$$Ca_nX_n = Ca_{n-1}X_{n-1} + [Ca_n - Ca_{n-1}]ZK + [KZ - X_{n-1}]F\,Ca_{n-1}$$

Ca_n is the calcium content of the bones of the 'n' years old in 1962.

X_n is the Sr^{90}/Ca ratio of the bones of the 'n' years old in 1962.

X_{n-1} is the Sr^{90}/Ca ratio of 'n–1' years old in 1961.

Z is the average Sr^{90}/Ca ratio of the diet from 10/61 to 9/62.

K is the diet-bone observed ratio appropriate to an individual of age between 'n–1' and 'n' years old.

F is the fraction of the skeleton exchanged during the year by an individual between 'n–1' and 'n' years old.

TABLE 3.—PREDICTED AND OBSERVED STRONTIUM-90 IN INFANT BONES

[pc Sr^{90}/g Ca]

City and Dates	Diet	Predicted		Observed
		ratio = 0.31	ratio = 0.25	
New York City				
3/61–3/62	10.1	3.1		3.4±1.5
10/61–9/62	11.6			
3/62–2/63	14.5	4.2	[a]3.8	3.8±1.3
San Francisco				
3/61–2/62	3.4	1.1		0.5±0.1
10/61–9/62	4.4			
3/62–2/63	5.6	1.5	[a]1.1	1.1±0.3

[a] Corrected for lack of complete equilibrium.

The left hand term of the equation is the total strontium–90 burden of an individual 'n' years old. The first term on the right is the total strontium–90 burden the individual had one year previously. The second term is the strontium–90 accreted during the year, since it is the increase in calcium multiplied by the Sr^{90}/Ca ratio of 'new' bone, i.e., diet Sr^{90}/Ca X diet-bone observed ratio. The last term is the strontium–90 added or lost due to resorption of calcium with a concentration of strontium–90 characteristic of 'old' bone and its replacement by bone having a strontium–90 concentration characteristic of 'new' bone.

Average values of X_n and X_{n-1} determined for bone samples obtained from children up to the age of 5 years at death in New York City and San Franscisco were substituted above. Values of Ca_n and Ca_{n-1} taken from Mitchell *et al* (*6*) and the estimates of Z for New York City for the period October 1961–September 1962 were also inserted above. The result was 8 equations with K and F the only unknowns. Estimates of the values for K and F that best fit the observed data were made by plotting K against F and determining the coordinates of points of intersection of the curves within the region bounded by K = 0 to K = 1 and F = 0 to F = 1. All of the values for K of these points were within a very narrow range while the values of F varied considerably. The mean values and standard deviations for the points of intersection were:

$$F = 0.51 \pm 0.20 \qquad K = 0.24 \pm 0.01$$

An idea of how well these values "fit" the data can be had by comparing predicted and observed bone strontium–90 concentrations of New York City and San Francisco children who died in the summer of 1962, as follows in table 4:

TABLE 4.—COMPARISON OF PREDICTED VS OBSERVED STRONTIUM-90 LEVELS IN CHILDREN'S BONES

City	Age at death (years)	pc Sr^{90}/g Ca	
		Predicted	Observed
New York City	1.5	3.04	3.05
	2.5	2.80	2.68
	3.5	2.65	2.61
	4.5	2.50	1.93
San Francisco	1.5	0.90	1.27
	2.5	0.85	1.53
	3.5	1.18	1.18
	4.5	1.18	1.15

Adults (>20 years old)

It has been shown that a reasonable estimate of K for adults, based on stable strontium measurements of diet and bone is 0.16 (*5*). If this value is inserted above, and setting $Ca_n = Ca_{n-1}$ for adults, the estimates of F from the data from New York City and Chicago are:

New York City, F = 0.08
Chicago, F = 0.34

Data from San Francisco were not used because, as can be seen from table 2, the standard deviation from the mean of X_n for adults from San Francisco was very great.

Errors

The average relative error due to counting for the set of 165 bone samples analyzed was 8.9 percent. Sixteen percent of the samples had counting errors less than 6 percent, 77 percent had counting errors less than 11 percent, and 93 percent had counting errors less than 16 percent.

In addition to the 165 samples analyzed, 25 samples were analyzed as part of the quality control program in operation at the Laboratory. These samples included a very low level standard analyzed 8 times, a high level standard analyzed 7 times, a low level standard analyzed 4 times, and 6 of the set of 165 samples which were analyzed as blind duplicates. The average relative error due to counting for this set of analyses was 17 percent.

Conclusions

Based on measurements of the strontium–90 content of the diet for the last three years and measurements of the strontium–90 content of human vertebrae obtained for the last two years,

it is concluded that the diet-bone observed ratio for children from 1 to 5 years old is about 0.24 and that the average annual exchange rate of their skeleton is about 51 percent. It is furthermore concluded that the diet-bone observed ratio for adult vertebrae is about 0.16 and that the annual exchange rate of vertebrae skeleton is about 8 percent. From specific activity calculations (Sr^{90}/Sr) in diet and bones of infants six months old, it is concluded that the exchange rate of the skeleton was from 60 to 80 percent. The diet-bone observed ratio of six-month-old infants may be higher than 0.25 but the data are not conclusive.

Only tentative conclusions could be reached, since they are based on a very limited number of samples taken at times of the year when diet levels of strontium–90 were changing greatly. It is hoped that more significant data will be available in the near future.

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Whole Body Counting

Whole body counters, utilizing high-pressure ionization chambers, liquid or plastic scintillators or thallium-activated sodium iodide crystals, are being applied to a number of problems of common interest to workers in the medical research and radiological health fields. Typical investigations involving whole body counting procedures include the rapid detection of low levels of gamma-emitting radionuclides, the identification of unknown radioactive contaminants, the monitoring of persons and foodstuffs, and the nondestructive, direct measurement of body potassium and low tracer doses of certain radionuclides in metabolic studies.

Cesium–137 measurements in residents of West Germany obtained by the U.S. Army Medical Research Unit, Landstuhl, Germany are reported below.

CESIUM–137 IN MAN
March–July 1963

U.S. Army Medical Research Unit, Landstuhl, Germany

Cesium–137 was first detected in man at the Argonne National Laboratory in 1955 (*1*). This nuclide emits a 0.661 Mev gamma photon, which can be quantitatively determined by a properly calibrated whole body counter. Since cesium is physiologically similar to potassium, and for the most part exists intracellularly, the cesium–137 levels are usually expressed in picocuries per gram of potassium.

The whole body counting facility at the Medical Research Unit, Landstuhl, Germany, utilizes a liquid scintillation counter in its program for measuring the cesium–137 levels in man (*2*). Results of analyses performed at Landstuhl from March through July 1963 are presented in table 1.

TABLE 1.—CESIUM–137 RESULTS OF WHOLE BODY COUNTING AT LANDSTUHL, MARCH—JULY 1963

Month	Number of subjects	Residence	Cesium-137 pc/g K (average)
March	211	West Germany	74
April	14	West Germany	84
May	298	West Germany	93
June	157	West Germany	90
July	187	West Germany	104

The values in table 1 represent an increase in body burden when compared with an average of 32 pc Cs^{137} per gram of potassium for March through July 1962. This increase tends to support recent predictions of average cesium–137 body burdens made by the Federal Radiation Council (*3*). Although the predictions were made strictly for the U.S., it can be assumed that they are generally applicable to West Germany.

The Federal Radiation Council has recommended (*4*) that the whole body dose to an individual in the general population be less than the Radiation Protection Guide (RPG) of 0.5 rem per year. It is recommended, further, that a population average whole body dose of 170 mrem per year not be exceeded. Also, The Council has stated (5) that the characteristics of cesium–137 lead to direct comparison of this nuclide with recommended whole body exposures. Calculations of the NCRP (*6*) indicate that a whole body burden for cesium–137 of 30,000 nc yields a whole body dose of 5 rem per year to an individual. Hence, an average body burden of 1000 nc may be taken as yielding a per capita whole body dose of 170 mrem per year to a suitable sample of the exposed population. If the highest value in table 1, 104 pc/gram potassium, is multiplied by 140 grams of potassium in a "standard man" (*7*), the resulting whole body burden, 15 nc, would yield about 1.5 percent of the appropriate RPG of 170 mrem.

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(*5*) Federal Radiation Council: Radiation Protection Guidance for Federal Agencies, Memorandum for the President, *Federal Register* (September 26, 1961).

(*6*) National Committee on Radiation Protection: *Maximum Permissible Body Burden and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure, National Bureau of Standards, Handbook 69*, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (June 5, 1959) price 35 cents.

(*7*) Public Health Service: *Radiological Health Handbook*, Office of Technical Services, U.S. Department of Commerce, (September 1960) price $3.75.

Recent Coverage in *Radiological Health Data*:

Period	*Issue*
First Quarter 1962	*August 1962*
Second Quarter 1962	*October 1962*
Third Quarter 1962	*December 1962*
July 1958—September 1962	*April 1963*
September—December 1962	*August 1963*

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors quarterly reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity data for 22 AEC installations have appeared periodically in *Radiological Health Data* since November 1960. The environmental monitoring summary for the Atomics' International facility is presented below.

ATOMICS INTERNATIONAL
Calendar Year 1962

Canoga Park, California

Atomics International, a division of North American Aviation, Incorporated, operates the Nuclear Development Field Laboratory (NDFL) and the World Headquarters Facility (WHF) at Canoga Park, California, under contract with the Atomic Energy Commission. The company designs, develops and constructs nuclear reactors for control station and compact power plants, and for medical, industrial, and scientific applications. Locations of the facilities are shown in figure 1.

The NDFL facilities include a 20-megawatt sodium reactor experiment (SRE) power reactor; several smaller experimental reactor facilities such as critical facilities Systems for Nuclear Auxiliary Power (SNAP) reactor, shield test facilities, and others; and extensive rolling and fuel fabrication operations. The WHF is primarily an administrative building but a small amount of fuel fabrication is conducted there. For this reason, the WHF area in included in the environmental monitoring.

Environmental monitoring is conducted at WHF and NDFL to test the effectiveness of radiological safety procedures and of engineering safeguards incorporated into facility design. Surface soil, vegetation, water and air samples are surveyed periodically.

Air Monitoring

Environmental air sampling is conducted continuously at the WHF and NDFL sites with

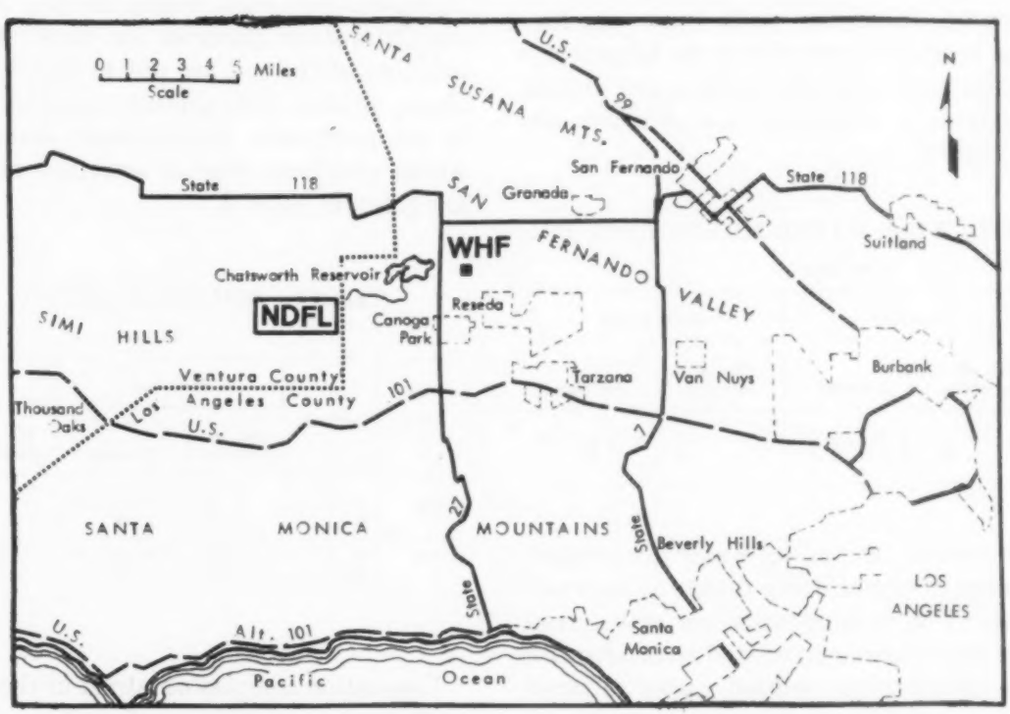

FIGURE 1.—ATOMICS INTERNATIONAL FACILITIES AND VICINITY

automatic air samplers operating on 24-hour sampling cycles. Airborne particulate radioactivity is collected on a stationary filter tape which is automatically changed at the end of each sampling period. The filter tape is removed, allowed to decay for 72 hours and counted in an automatic proportional counting system. The volume of a typical daily air sample is approximately 21 cubic meters. The minimum detection limit is on the order of 0.02 pc/m³. Averages for beta-gamma activity in airborne particulates are given in table 1.

TABLE 1.—AIRBORNE BETA-GAMMA ACTIVITY AT ATOMICS INTERNATIONAL, CALENDAR YEAR 1962

[pc/m³]

Type of sample and minimum detection levels	Location	First half 1962		Second half 1962	
		No. of samples	Average concentration	No. of samples	Average concentration
Air (β-γ = 0.04 pc/m³)	WHF	163	8.5	180	6.2
	NDFL	148	6.3	166	4.9

Water Samples

Process water at the NDFL is obtained from wells and stored in 50,000 gallon tanks. Monthly samples are collected from these wells (see table 2). Potable water is obtained in bottles delivered to the site and is, therefore, not analyzed. Process water is drawn from the wells into one liter polyethylene bottles for transfer to the laboratory. Water samples from the lake surface and supply inlet of Chatsworth Reservoir are similarly obtained (see table 3).

TABLE 2.—NDFL WELL WATER MONITORING, 1962

[pc/liter]

Activity	First half		Second half	
	No. of samples	Average	No. of samples	Average
α	12	0.09 to 0.11	12	0.30 to 0.32
β-γ	12	3.1 to 3.2	12	20

In the laboratory, 500 ml. of water are evaporated to dryness in crystallizing dishes at approximately 90°C. The residue salts are transferred into stainless steel planchets, wetted to produce an even sample distribution, redried under infrared lamps, and counted in an automatic proportional counting system.

TABLE 3.—CHATSWORTH RESERVOIR WATER SAMPLING, 1962

[pc/liter]

Sample Type	Activity	First half		Second half	
		No. of samples	Average	No. of samples	Average
Lake surface	α	21	0.46 to 0.47	20	0.88
	β-γ	21	20	20	17
Supply inlet	α	6	.50	6	0.50
	β-γ	6	12	6	14

Soil and Vegetation Samples

Soil and vegetation are sampled monthly at 51 locations. Thirteen sampling stations are located within the boundaries of Atomics International and are designated as one-site stations. The remaining 38 stations are located within a 10-mile radius of Atomics International and are referred to as off-site stations. Several of the off-site stations are located at Chatsworth Reservoir, which is operated by the Los Angeles City Department of Water and Power.

Surface soil samples range from decomposed granite to clay and loam and are collected from the top ½-inch layer of ground surface. The samples are placed in plastic containers and sent to the laboratory. Sample preparation consists of drying the soil in a muffle furnace at 500°C. for approximately eight hours, cooling, and sieving to obtain uniform particles for counting. One-gram aliquots of the soil are put in stainless steel planchets, wetted with acetone, redried, and counted in an automatic proportional counting system. Alpha and beta-gamma activities of soil samples are given in table 4.

TABLE 4.—SOIL RADIOACTIVITY, 1962

[pc/gm]

Area	Activity	First half		Second half	
		No. of samples	Average	No. of samples	Average
On site	α	69	0.40 to 0.42	78	0.44 to 0.46
	β-γ	69	43	78	52
Off site	α	227	0.31 to 0.38	226	0.39 to 0.44
	β-γ	227	42	226	53

Vegetation samples obtained in the field at each station are generally sunflower or wild tobacco plant leaves. The leaves are stripped from the

plant and washed to remove foreign matter at the laboratory. The vegetation, after a distilled water rinse, is ashed in a muffle furnace at 500°C. for approximately eight hours. This produces a completely oxidized ash of uniform density. Three hundred-milligram aliquots of ground ash are used for counting in an automatic proportional counting system. Vegetation data are shown in table 5.

TABLE 5.—VEGETATION RADIOACTIVITY, 1962

[pc/gm ash]

Area	Activity	First half		Second half	
		No. of samples	Average	No. of samples	Average
On site	α	69	0.37 to 0.39	78	0.49 to 0.51
	β-γ	69	702	78	321
Off site	α	227	0.30 to 0.32	226	0.54 to 0.55
	β-γ	227	558	226	253

REPORTED NUCLEAR DETONATIONS

October 1963

Four nuclear detonations at the Nevada Test Site during October 1963 were announced by the Atomic Energy Commission.

The first two of these were low yield underground tests conducted on October 11, one of which was a weapons-related test and the other was a part of the Commission's Plowshare Program to develop peaceful uses for nuclear explosives.

On October 16, a test of intermediate yield was conducted underground at the Site. (Low yield range means less than 20 kilotons; intermediate yield range is from 20 kilotons to one megaton.)

On October 26, a nuclear explosion of about 12 kilotons yield took place 1,200 feet underground in a remote area about 28 miles southeast of the town of Fallon, Nevada. This test, called Project Shoal, was a part of the Department of Defense research program to improve systems for detecting and identifying underground nuclear explosions.

Arbitrary reference numbers assigned by *Radiological Health Data* to the four October tests are, in the order mentioned above, 139 to 142.

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UNITS AND EQUIVALENTS

Symbol	Unit	Equivalent
Bev	billion electron volt	
cpm	count per minute	
dpm	disintegration per minute	
g	gram	
kg	kilogram	1 kg = 1000 gm = 2.2 pounds
km^2	square kilometer	
kvp	kilovolt peak	
m^3	cubic meter	1 m^3 = 1000 liters
ma	milliampere	
mas	milliampere-second	
Mev	million electron volts	
mi^2	square mile	
ml	milliliter	
mm	millimeter	
mrad	millirad	
mrem	millirem	
mr/hr	milliroentgen per hour	
mμc	millimicrocurie	1 mμc = 1 nc
nc	nanocurie	1 nc = 1000 pc = 1 mμc = 10^{-9} curies
nc/m^2	nanocurie per square meter	1 nc/m^2 = 1 $m\mu c/m^2$ = 1,000 $\mu\mu c/m^2$ = 1 mc/km^2 = 2.59 mc/mi^2
pc	picocurie	1 pc = 1 μμc = 10^{-12} curies
r	roentgen	
μμc	micromicrocurie	1 μμc = 2.22 dpm

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr′ a
10^{9}	giga	G	jĭ′ ga
10^{6}	mega	M	mĕg′ a
10^{3}	kilo	k	kĭl′ o
10^{2}	hecto	h	hĕk′ to
10	deka	da	dĕk′ a
10^{-1}	deci	d	dĕs′ ĭ
10^{-2}	centi	c	sĕn′ tĭ
10^{-3}	milli	m	mĭl′ ĭ
10^{-6}	micro	μ	mī′ kro
10^{-9}	nano	n	năn′ o
10^{-12}	pico	p	pē′ co
10^{-15}	femto	f	fĕm′ to

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